This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

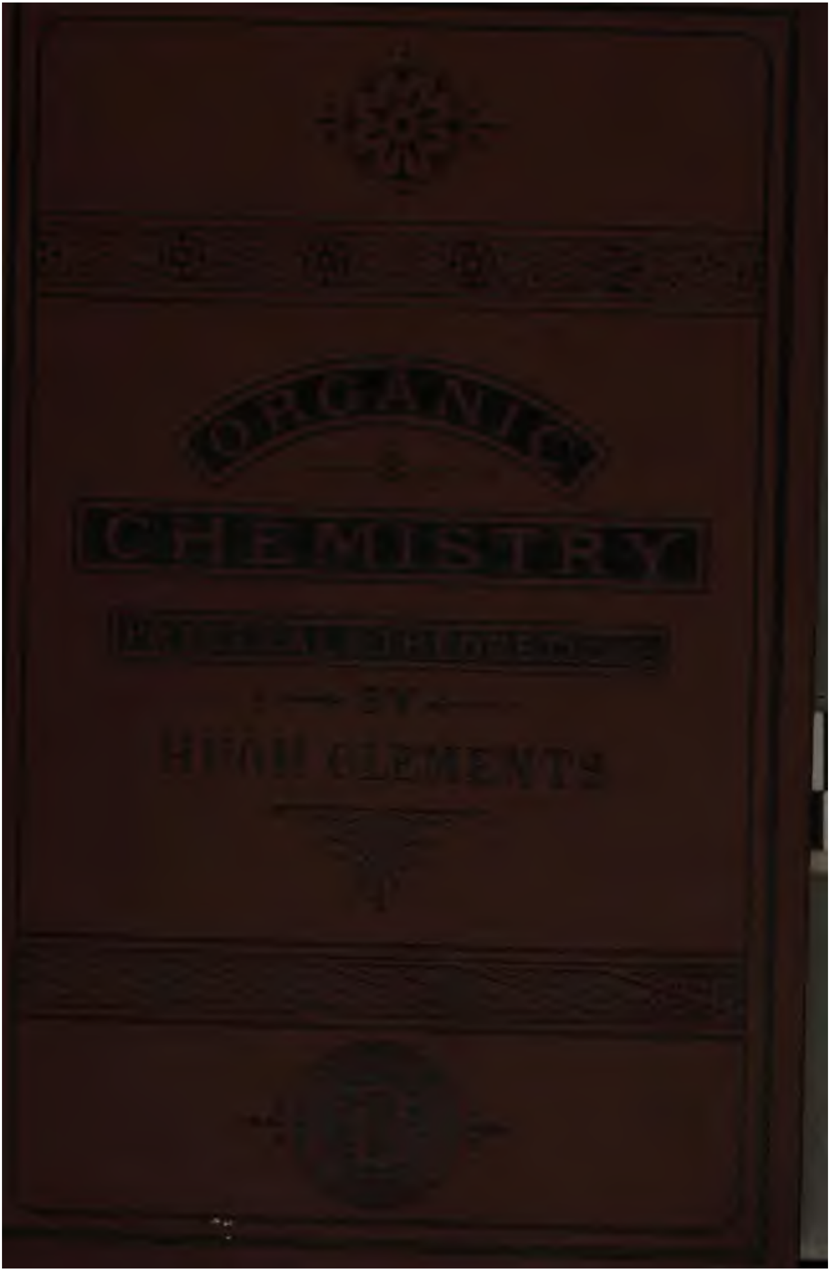
+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`



ORGANIC CHEMISTRY

[illegible]

BY

HUGH CLEMENTS

A MANUAL

OF

ORGANIC CHEMISTRY,

PRACTICAL AND THEORETICAL,

FOR COLLEGES AND SCHOOLS,
MEDICAL AND CIVIL SERVICE EXAMINATIONS, AND
ESPECIALLY FOR ELEMENTARY, ADVANCED, AND HONOURS STUDENTS
AT THE CLASSES OF THE SCIENCE AND ART DEPARTMENT,
SOUTH KENSINGTON.

BY

HUGH CLEMENTS,
Of H.M. Civil Service,
President of the Amateur Mechanics' Workshops Association, London,
And Lecturer on Various Sciences at St. Thomas', Charterhouse, and several other
Science Institutions in London.

Lucem Libris Disseminamus

BIBLIOTHECA
JUL 1879
BODLEIANA

LONDON:
BLACKIE & SON, 49 & 50 OLD BAILEY, E.C.
GLASGOW, EDINBURGH, AND DUBLIN.
1879.

193 . g . 136

GLASGOW:
W. G. BLACKIE AND CO., PRINTERS,
VILLAFIELD.

PREFACE.

THIS work appeared in a serial form in the *English Mechanic and World of Science* down to the end of the "Identifications of Organic Bodies."

The remainder of the work, for obvious reasons, did not appear in that journal, and the Author hopes that this latter portion will meet with as much approbation as did the former.

The original idea was to adapt the work to suit the requirements of the Elementary and Advanced Syllabus of the Science and Art Department; but the Author hopes that by the extra matter appended, and the answers to the questions given at the May examinations during the last ten years on the Elementary, Advanced, and Honours Stages, that the work will enable Students to pass in Honours, and also form a text-book for Students at Public Schools and Colleges, and candidates preparing for Medical, Civil Service, or other examinations.

HUGH CLEMENTS.

SYLLABUS

OF THE SCIENCE AND ART DEPARTMENT.

SUBJECT XI.—ORGANIC CHEMISTRY.

ELEMENTARY COURSE.

Pupils presenting themselves for examination will be expected to possess a knowledge of the following subjects:—

Definition of organic bodies; their ultimate analysis. Calculation of empirical formulæ. Compound organic radicals. Notation of organic compounds. Graphic and symbolic formulæ.

Organic Radicals.—Positive radicals. Preparation and properties of the monad radicals of the methyl series. Monad radicals of the vinyl and phenyl series.

Dyad positive radicals of the ethylene series. Preparation and properties of ethylene.

Negative radicals. Cyanogen. Oxatyl. Oxalic acid, its preparation and properties.

Hydrides of the Organic Radicals.—Methylic hydride or marsh-gas. Paraffin. Benzol. Cyanic hydride or hydrocyanic acid. Oxatylic hydride or formic acid.

The Alcohols.—Definition of an alcohol. Methylic alcohol. Ethylic or common alcohol. Phenylic alcohol or carbolic acid.

The Ethers.—Definition. Preparation and properties of ethylic ether.

The Haloid Ethers.—Their constitution. Preparation and properties of ethylic chloride and iodide.

The Aldehydes.—Their nature and properties. Acetic aldehyde. Benzoic aldehyde or oil of bitter almonds.

The Acids.—Definition of an organic acid. Acetic acid. Lactic acid. Benzoic acid.

Ethereal Salts.—Definition and constitution of the ethereal salts of the monobasic acids. Preparation and properties of acetic ether and butyric ether.

The evidence of a good knowledge of chemical manipulation will be rewarded by special extra payments. (See § XLIV. of the Directory.) This knowledge will at present be tested by questions set with the ordinary examination paper in May, and the course of laboratory practice to which the questions will be confined will be the preparation of ethyl, ethylene, cyanogen, oxalic acid, marsh-gas, hydrocyanic acid, ethylic alcohol, ethylic ether, ethylic iodide, acetic acid, lactic acid, and ethylic acetate or acetic ether. The analytical detection of hydrocyanic acid, oxalic acid, tartaric acid, citric acid, and acetic acid.

ADVANCED COURSE.

In addition to the above subjects, students presenting themselves for this examination will be assumed to be acquainted with the following:—

Determination of the rational formulæ of organic acids and bases. Graphic and symbolic types of organic compounds. Reduction and development of the formulæ of organic bodies. Classification of organic compounds.

Organic Radicals.—Dyad positive radicals of the acetylene series. Single and double cyanides. Manufacture of prussian blue and of oxalic acid.

Hydrides of the Organic Radicals.—Ethylic and amylic hydrides. Hydrides of the radicals of the phenyl series. Manufacture of coal-gas.

The Alcohols.—Classification, preparation and properties of alcohols. 1. Monacid alcohols; methyl series, vinyl series, allyl series, phenyl series. 2. Diacid alcohols or glycols; ethylic glycol and its derivatives. 3. Triacid alcohols; glycerine, its preparation and properties.

The Ethers.—1. Ethers of the monacid alcohols;—methylic ether, allylic ether, phenylic ether. 2. Ethers of the diacid alcohols;—ethylenic oxide. 3. Ethers of the triacid alcohols;—glycylic ether.

The Haloid Ethers.—Haloid ethers of the monad, dyad, and triad positive radicals. Methylic chloride. Manufacture of chloroform. Ethylenic bromide.

The Aldehydes.—Formation and reactions of the aldehydes of the methyl, vinyl, and phenyl series of alcohols.

The Acids. —Law of basicity of organic acids.

Monobasic acids:—Acetic or fatty series. Acrylic or oleic series. Lactic series. Pyruvic series. Glyoxylic series. Benzoic or aromatic series.

Dibasic acids:—Succinic series. Fumaric or acryloid series. Malic or lactoid series. Tartaric or glyoxyloid series.

The Anhydrides.—Definition and constitution of the anhydrides. Formation and reactions of the anhydrides of monohydric monobasic acids, dihydric monobasic acids, and of dihydric dibasic acids.

The Ketones.—Derivation and constitution of the ketones. Preparation and properties of acetone.

Ethereal Salts.—Ethereal salts of dibasic and tribasic acids, and of monacid, diacid, and triacid alcohols.

Organic compounds containing Nitrogen, Phosphorus, Arsenic, and Antimony.—The more important natural and artificial alkaloids. Extraction of quinine from cinchona bark.

Organo-metallic Bodies.—Definition. Their behaviour and formation. Preparation and properties of zincic ethide, mercuric ethide and stannic ethide.

The evidence of a good practical knowledge of organic analysis, and of experimental manipulation will be rewarded by special extra payments. (See § XLIV. of the Directory.) This knowledge will be tested by questions set with the ordinary examination paper. In this stage the practical questions may include, besides those enumerated under the first stage, the quantitative analysis of organic bodies containing carbon, hydrogen, oxygen, and nitrogen; and the preparation of acetylene, ethylic hydride, amylic alcohol, phenylic alcohol, ethylic glycol, glycerine, ethylenic oxide, chloroform, benzoic aldehyde, acrylic acid, malic acid, succinic acid, acetic anhydride, acetone, ethylamine, and zincic ethide.

HONOURS COURSE.

In addition to the above, the candidate should be well acquainted with the following subjects:—

Determination of the specific gravity of gases and vapours. The methods employed in the analysis of gaseous organic bodies. Synthesis of organic compounds. Determination of the constitutional formulæ of organic bodies. Isomerism, metamerism, and polymerism in organic bodies.

Organic Radicals.—Normal, secondary, and tertiary monad radicals. Isomerism of ethylene and ethylidene compounds. Relations between methyl, oxatyl, and cyanogen.

Hydrides of the Organic Radicals.—Relations of the positive monad radicals to their hydrides.

The Alcohols.—Relations of the normal monacid alcohols to the monad C_nH_{2n+1} radicals, the dyad C_nH_{2n} radicals, and to the hydrides of the C_nH_{2n+1} radicals.

Secondary monacid alcohols. Isopropylic, pseudamylic, and pseudohexylic alcohols.

Tertiary monacid alcohols. Pseudobutylic alcohol.

Normal and secondary alcohols of the phenyl series.

Relations of glycerine to isopropylic and allylic alcohol; also to glyceric, tartronic, and acrylic acid.

Other polyacid alcohols:—Erythrite, mannite, glucose.

The Acids.—Difference between hydricity and basicity of acids.

Normal, secondary, and tertiary fatty acids. Relations of the fatty acids to the C_nH_{2n+1} series of radicals, and to the $C_nH_{2n+1}Ho$ series of alcohols. Relations of the fatty acids to each other; ascent of the series.

Normal, secondary, and olefine acids of the acrylic or oleic series. Relations of the acrylic to the acetic series of acids.

Definition and classification of the acids belonging to the lactic series. Relations of the lactic to the fatty and acrylic series of acids. Isomerism in the lactic series.

Relations of the pyruvic series of acids to the oxalic and lactic series.

Relations of the glyoxylic series of acids to the glycerine series of alcohols.

Constitution and classification of the dibasic acids. Relations of the succinic series of acids to the lactic and acetic series, and to the glycols.

Isomerism in the fumaric series of dibasic acids.

Tartaric or glyoxyloid series of dibasic acids. Varieties of tartaric acid.

Constitution and classification of the tribasic acids.

The Ketones.—Isomerism in the ketone family.

Organic Compounds containing Nitrogen, Phosphorus, Arsenic, and Antimony.—The amines, phosphines, arsines, and stibines. Primary, secondary, and tertiary organic bases. Monamines, diamines, triamines, and tetramines.

Organo-metallic Bodies.—Their constitution and its bearing upon the doctrines of atomicity.

CONTENTS.

PAGE
Syllabus of the Science and Art Department, ... v
Introduction, ... 1
Detection of Carbon, Hydrogen, and Oxygen in Organic Compounds, 3
Empirical and Rational Formulæ, ... 7
Determination of Molecular Formulæ and Weights, ... 10
Estimation of Nitrogen, Sulphur, Phosphorus, Arsenic, and the Halogens in Organic Bodies, ... 11
Organic Substitution Products, ... 14
Theory of Compound Organic Radicals, ... 20
Notation of Organic Compounds, ... 24
Preparation and Properties of the Hydrides of the Organic Radicals, Coal-gas, Prussian Blue, &c., ... 25
The Distillation of Coal, ... 41
The Alcohols, ... 45
The Ethers, the Haloid Ethers, and Ethereal Salts, ... 51
Methyl Chloride, Chloroform, Ethylenic Bromide, ... 59
The Aldehydes, ... 61
Organic Acids, ... 66
The Anhydrides, ... 74
The Ketones, ... 78
The Alkaloids, Cyanic Acid, Cyanates, and Urea, ... 79
Organo-boron and Silicon Compounds, ... 91
Organo-metallic Bodies, ... 94
Identification and Analysis of Organic Compounds of Technical and Commercial Importance, ... 98
Oils—Fixed and Essential, ... 144
Apparatus for the Preparation and Analysis of Organic Bodies, . 163
Exercises for Elementary, Advanced, and Honours Students, . 172
Papers set in Organic Chemistry in the Elementary, Advanced, and Honours Stages at the Examinations of the Science and Art Department during the *last ten years*, with Answers, 182
Appendix: List of the Elements, Tables of Weights and Measures, &c., ... 269

INDEX, ... 275

ORGANIC CHEMISTRY.

DISTINCTION BETWEEN ORGANIC AND INORGANIC SUBSTANCES.

Many definitions have been given of organic chemistry, but they are all more or less inaccurate. A definition of any term should separate it from every other thing, just as a boundary separates one field from another.

But it would appear that there is a difficulty in distinguishing in every case an organic from an inorganic substance. Hence the difficulty in defining the term organic chemistry. If we define it at all we must include too much or too little—*i.e.*, we must include some compounds that are clearly inorganic, or exclude some that are as plainly organic. For instance, Laurent defined organic chemistry as the chemistry of carbon; but this definition includes carbon itself, its oxides, and other substances which are generally considered inorganic.

Again, Liebig defined it as the chemistry of the compound radicals, which would, of course, include the inorganic compound radicals. Further, it has been defined as the chemistry of the products of animal and vegetable life; but as many of these products can be produced artificially, this definition has been discarded; and I dare say if we fully understood the processes which are constantly at work in the bodies of animals and plants, we could artificially produce many more.

According to Frankland organic chemistry is restricted to compounds *consisting* of one or more atoms of carbon, *directly combined with* carbon, nitrogen, or hydrogen, excluding carbonic anhydride, and hydric potassic carbonate, in which the carbon is directly combined with oxygen only. But this definition does not seem to be an improvement on the others, for it excludes all the other elements, besides nitrogen and hydrogen, which are found in organic compounds, and in other cases we have to write out graphic formulæ in order to discover whether or not the carbon is directly combined with oxygen. By far the best definition is that which makes it the chemistry of the carbon compounds. For this definition includes every possible organic substance, and but few inorganic ones, so that the definition is defective to the extent it includes strictly inorganic substances. It properly excludes carbon, which is never found in the free state in organized life. It includes carbonic anhydride, which chemists generally consider to be inorganic; but I think, as this gas is a product of the respiration of animals, it is decidedly an organic product, and should therefore be included with organic compounds. Of course there are many substances which can, with equal propriety, be classed either as organic or inorganic, but this does not warrant us in excluding those bodies from the domain of organic chemistry.

Thus we see that many organic substances have no absolute character to distinguish them from inorganic. Every organic substance contains carbon, but every substance that contains carbon is not organic. As a general rule organic compounds are distinguished by their complexity—some containing upwards of 300 atoms in the molecule, while inorganic substances scarcely ever contain more than a dozen.

Hydrocyanic acid is the only instance of an organic molecule containing but three, while there are many examples of an inorganic molecule containing only two atoms. As a rule organic products are composed of a small number of elements. Many consist of carbon and hydrogen only, as the ethine and paraffin series of hydrocarbons, but the largest class contains carbon, hydrogen, and oxygen combined, as in the alcohols, acids, aldehydes, sugar, fixed oils, and most of the proximate principles of vegetables. Nitrogen is also found combined with carbon, hydrogen, and oxygen in a large class of substances, as in the highly organized parts of animals and plants, amines, amides, and the natural alkaloids.

But sulphates, chlorides, phosphates, and silicates are always found in small quantities in organized bodies, and more rarely bromides, fluorides, iodides, and salts of iron and manganese. Again, organic bodies are distinguished from inorganic by their chemical instability, their proneness to continual change. These changes of chemical composition in the plant and animal follow each other in a definite and systematic order, and when this order is interrupted to a certain extent disease and death ensue.

ORGANIC ANALYSIS AND EMPIRICAL FORMULA.

As all organic substances contain carbon, it is not necessary to perform an analysis to detect the presence of that element; but as all organic compounds do not contain hydrogen, oxygen, or nitrogen, it is necessary to perform an analysis in order to determine these elements. If an organic compound containing C, H, and O be treated with cupric oxide, and the products of combustion be absorbed in suitable apparatus, we can determine the amount of carbon, hydrogen, and oxygen present.

A general idea may be formed of the methods adopted in the quantitative analysis of an organic compound, such as sugar, containing carbon, hydrogen, and oxygen, from the annexed figure and description.

A charcoal furnace made of sheet iron, in the form of a trough, answers this purpose very well, and is not expensive. Fig. 1 represents a gas furnace in which there are twenty-four Bunsen burners, *b b*, each having a separate stopcock, so that the flame can be controlled at pleasure.

Each ends in a horizontal pipe connected with a gas supply by *g*. The flame impinges on a fire-clay trough, in which is placed the combustion tube *t*, round which are clay plates, *a*, *a*, to prevent the escape of heat, and throw it back on the combustion tube, heating it uniformly. The combustion tube is longer than the furnace, and is made of Bohemian glass.

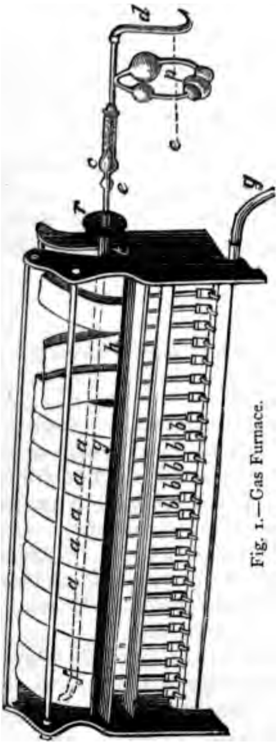


Fig. 1.—Gas Furnace.

A circular disc of copper, *r*, protects the calcium chloride tube from the heat of the furnace. The calcium chloride tube *c* has two bulbs, *c* and *e*, between which a thin glass tube is fused, passing into *e*. The large bulb and tube are filled with small pieces of spongy calcium chloride, which absorb every particle of water given off during combustion; but if the quantity of water is small it is condensed in the smaller bulb. The potash bulbs *p* are filled up to the dotted line *l* with a solution of three parts of potash in two of water. This solution absorbs all the carbonic anhydride produced by combustion.

If the dotted line over the plates *a*, *a*, represents the combustion tube which the side-plates hide from view, then from *f* to the tail of the tube is filled with pure cupric oxide, from *f* to *g* with a mixture of the sugar and oxide, from *g* to *h* with the rinsings of the mixture, and from *h* to about an inch of the cork with oxide; or about one-fourth of the combustion tube is filled with copper oxide, the sugar weighed in a little glass tube, and shaken into the combustion tube and thoroughly mixed with the oxide by raking them together by a wire. The remainder of the tube is filled with oxide; or the sugar may be put in a platinum boat that will pass into the tube. In Erlenmeyer's furnace the combustion tube is connected with large U calcium chloride tubes to the left, and these with a wash-bottle containing potash solution, so that air or oxygen passed through the tube may be dehydrated and robbed of carbonic anhydride. When commencing, heat the combustion tube and pass a current of dry air through it; at the same time weigh the calcium tube and potash bulbs without stoppers. After 10 or 12 minutes turn down the burners beneath the tube, and allow it to cool in a current of dry air. The platinum boat is heated to redness, and cooled in a desiccator. It is now weighed, and ·3 gramme of powdered sugar, dried in a steam bath, is transferred to the boat or tube. Now stop the air current passing through the tube, attach the calcium tube by a caoutchouc stopper to the combustion tube, and connect the potash bulbs with the calcium tube by caoutchouc tubing. A tube, *d*, filled with caustic potash in small pieces is attached by a cork to the free end of the potash bulbs, or the end of the potash bulbs is connected with a soda-lime tube, and this with a bell-jar standing in water, by which the pressure can be regulated. The sugar being inserted in the tube and all ready, gradually heat the tube, beginning at the right till it is red-hot, and light more burners until it is at a dull red-heat. Light three of the burners to the left, and successive burners to raise fresh parts of the oxide to a dull red-heat nearly to the sugar.

Now light a burner under the sugar, gently heat it when the sugar melts, turns brown, and gives off vapour and gas. The gas passes to the potash bulbs, and the heat should be regulated so that it passes uniformly. The sugar is charred, and the passage of gas almost ceases when all the burners are turned on, and a bubble of oxygen is sent through the apparatus till no gas is absorbed. The burners are gradually lowered, and the tube of the wash-bottle is connected with an air gasometer, and air passes through to displace the oxygen. Let the tube cool gradually. Detach the calcium tube and potash bulbs, wipe them clean, and weigh. When a charcoal furnace is used, and we have arrived at that stage of the process when no bubbles of gas are given off and the potash solution recedes into the larger bulb, the charcoal is removed from the tail of the tube at *f*, and the end of the tail is broken off, when the potash fills about half of the larger tube. Air is drawn into the tube by suction of a caoutchouc tube attached to the end of the potash bulbs, to expel any watery vapour or carbonic anhydride. The calcium tube and potash bulbs are detached and weighed. The potash bulbs weighed 75·375 grammes before combustion, and 75·838 after, the difference being ·463 gramme, the weight of carbonic anhydride. The calcium tube before combustion weighed 22·346 grammes, and after it weighed 22·520 grammes, the difference being ·174, the amount of water produced.

Carbonic anhydride contains 1 atom of carbon and 2 of oxygen. The atomic weight of the carbon is 12, and that of the 2 atoms of oxygen is 32—the sum is 44; therefore, 44 parts of carbonic anhydride will contain 12 parts of carbon, or 11 parts will contain 3 of carbon. By taking 3-11ths of ·463 we obtain ·126 gramme of carbon. Water contains 1 atom of oxygen to 2 of hydrogen. The atomic weight of oxygen is 16, and 2 of hydrogen makes 18, so that every 18 parts of water contains 2 parts of hydrogen, or 9 contains 1 of hydrogen.

And 1-9th of ·174 gives ·019 as the weight of hydrogen *in the ·3 gramme* of sugar. Now add together ·126 *gramme of carbon* and ·019 gramme of hydrogen, we *have ·145 gramme,* the sum of the carbon and hydrogen, which, taken from ·3 gramme, the weight of the sugar taken, we obtain ·155 gramme as the weight of the oxygen.

In the ·3 gramme of sugar there is ·126 carbon, ·019 hydrogen, and ·155 oxygen.

To find the percentage composition, say, as—

·3 : ·126 :: 100 : percentage of carbon.
·3 : ·019 :: 100 : percentage of hydrogen.
·3 : ·155 :: 100 : percentage of oxygen.

and obtain 42·11 carbon, 6·43 hydrogen, and 51·46 oxygen. Divide these numbers by 12, 1, and 16 respectively, and obtain 3·51 carbon, 6·43 hydrogen, and 3·22 oxygen. Divide these numbers by 3·22, the least, and obtain 1·09 carbon, 2 hydrogen, and 1 oxygen, and multiply by 11, and obtain 12, 22, and 11 respectively, and write the formula for sugar as $C_{12}H_{22}O_{11}$, which is the empirical as well as the rational formula.

METHODS FOR THE DETERMINATION OF THE RATIONAL FORMULÆ OF ORGANIC SUBSTANCES—THE ESTIMATION OF NITROGEN—THE HALOGENS, SULPHUR, ARSENIC, AND PHOSPHORUS IN ORGANIC MATTER.

I have shown above how the empirical formula is obtained. To obtain the rational formula from the empirical formula it is necessary to determine the specific gravity of the substance in the state of vapour, either by determining the volume of a certain weight of the substance when in a vaporous condition, or by determining the weight of a given volume of the vapour. Or the rational formula of an organic substance possessing basic or acid properties may be determined from the weight of the acid combining with the *basic substance*, or from the percentage weight *of the base uniting* with the acid. Or, when possible, by forming a double chloride with platinum, and heating the compound to determine the percentage weight of platinum from which the rational formula may be calculated. Or it may be determined by the decompositions which the substance undergoes.

Suppose, for instance, we wish to determine whether CH_2O_2, which we have found as the empirical formula for formic acid, is also the rational formula, we take a glass globe having a capacity of 200 cc. or 300 cc., having a neck drawn out to a point. We weigh the globe, and introduce a sufficient quantity of formic acid. The globe is plunged into an oil-bath of a temperature of, say 140° C., shown by a thermometer. The formic acid boils, vapourizes, and expels the air, and issues from the point of the globe. When the rush of vapour ceases, melt the point of the globe with a blowpipe, and observe the temperature of bath and height of barometer. Now remove the globe, clean and weigh, and note the height of the barometer and temperature in the balance case. Then break the point of the globe under mercury, and determine the volume of mercury which fills the globe. For instance, in the determination of the formula for formic acid, the weight of the balloon and air was 24·8113 grm., the temperature of the oil-bath was 140° C., the height of the barometer when sealing was 750 mm.; the weight of the balloon filled with vapour was 24·8537; the temperature at weighing was 20° C., and the height of the barometer at weighing was 740 mm., and the volume of the balloon was 250 cc. The 250 cc. of air at 20° C. and 740 mm. become at 0° C. and 760 mm. 226·8 cc., which is found by dividing 250 × 273 × 740 by 293 × 760. And as 1 litre of air weighs 1·2936 grm. at the standard temperature and pressure, 1 cubic centimetre will weigh ·0012936 grm., and 226·8 cc. will weigh ·2934 grm. Then the weight of the vapour of formic acid filling the globe is 24·8537 grm. + ·2934 grm. − 24·8113 grm., equal to ·3358 grm.

Again, 250 cc. at 140° C. and 750 mm. become at 0° C. and 760 mm. 163·1, found by dividing 250 × 273 × 750 by

413 × 760. And 163·1 cc. of hydrogen will weigh 163·1 × ·0000896, equal to ·01461376 grm., which, divided into ·3358 grm., gives 23, which is the specific gravity of formic acid in relation to hydrogen as unity; therefore its molecular weight will be 46, in reference to a molecule or 2 atoms of hydrogen. And by adding together separately the equivalent weights of the carbon, hydrogen, and oxygen in the formula HCOHO, we obtain the number 46. Therefore, this is the correct rational formula, and not $C_2H_4O_4$, or any other multiple of CH_2O_2.

The rational formula for organic substances soluble in water or alcohol may be determined by adding to this solution some soluble metallic salt, the base of which is known to unite with the organic substance and form a salt. When the salt of the substance has been isolated and washed from adhering impurities and dried a weighed quantity is incinerated, so that nothing but the metal is left.

From the weight of the metal the molecular weight of the substance can be found. For example, the rational formula of acetic acid may be obtained by preparing silver acetate by adding a solution of potassic acetate to a concentrated solution of argentic nitrate, when argentic acetate is formed. This salt, being sparingly soluble in cold water, is readily separated from the potassic nitrate. When the precipitate has been washed and dried a given weight of it is heated in a crucible, when it is decomposed, metallic silver being left in the crucible. The weight of the silver deducted from the weight of the argentic acetate taken will give the weight of the acetic radical combining with it.

On incinerating 5 grm. of argentic acetate, 3·2325 grm. of metallic silver are left, and this deducted from 5 gives 1·7673, the loss in weight. Then, as 3·2325 : 108, the atomic weight of silver, so is 1·7673 : 59. To the 59 add 1 for the atom of hydrogen which was displaced by the monad silver in the acetate, and we obtain 60 as the molecular weight of acetic acid. By analysis the empirical formula CH_2O is obtained; but as the sum of $12+2+16$ is 30, just one-half of the number obtained, we double the atoms of each element, and obtain $C_2H_4O_2$ as the rational formula of acetic acid. And as all acids contain one or more semi-molecules of oxatyl we write it thus: CH_3COHO.

The rational formula for organic bodies, such as morphine, aniline, quinine, &c., which unite with HCl and form the hydrochlorate, may frequently be obtained by finding the weight of HCl which a given weight of these bodies absorbs, and saying as the weight of HCl absorbed is to 36·5, so is the given weight of the substance to its molecular weight, from which we can obtain the rational formula.

Again, these hydrochlorates often combine with $PtCl_4$, and form double chlorides, which, on being heated, leave platinum alone. Then say, as the weight of the platinum is to 197, its atomic weight, so is the weight of the double chloride to the molecular weight of the double chloride, from which the molecular weight of the given base may be obtained as well as its rational formula.

The rational formula may sometimes be determined from inference—thus it is found that when chlorine acts on marsh-gas the hydrogen is eliminated at four different steps, forming four different compounds, CH_3Cl, CH_2Cl_2, $CHCl_3$, and CCl_4, and the rational formula CH_4 is confirmed by the vapour density.

Again, when the hydrocarbon expressed by CH_3 is acted on by chlorine, six different compounds, C_2H_5Cl, $C_2H_4Cl_2$, $C_2H_3Cl_3$. $C_2H_2Cl_4$, C_2HCl_5, and C_2Cl_6, are formed. The rational formula is C_2H_6, and this is confirmed by the vapour density.

The vapour density of any substance may be found by dividing its molecular weight by twice 14·49, or 28·98, the weight of a given bulk of air compared with the weight of the molecule of hydrogen. Thus in the case of marsh-gas, CH_4, the molecular weight is $12+4=16$, which, divided by 28·98, gives ·552, which agrees with experiment. The molecular weight of methyl $(CH_3)_2$ is 24+6 =30, which divided by 28·98 gives 1·035 as its vapour density.

Again, when the vapour densities are multiplied by 28·98 we obtain a number from which we can make up the rational formula, provided we know the elements that enter into its composition. Thus ·552, the vapour density of marsh-gas or methyl hydride, multiplied by 28·98, gives 16. As this gas contains only carbon and hydrogen there must be at least 1 atom of carbon, and in this case there cannot be 2. There must necessarily be one of carbon (12) and four of hydrogen (1), making (16) the molecular weight.

When an organic substance contains nitrogen it is usual to determine the carbon and hydrogen in one portion, and the nitrogen in another.

When nitrogenous substances are burned with copper oxide, compounds of nitrogen and oxygen are liable to be formed, and pass into the calcium tube and potash bulbs, and thus render the results obtained inaccurate. But by passing the products of combustion over heated metallic copper, before leaving the combustion tube, the oxygen unites with the copper, while the nitrogen passes onward through the apparatus unabsorbed. There are two methods of determining the amount of nitrogen in an organic compound, according as the nitrogen is all given off in the form of ammonia when heated with an alkali or not.

In estimating the nitrogen by the ammonia process, a combustion tube is required of about 16 inches long, and about $\frac{4}{10}$ths of an inch in internal diameter. A layer of oxalic acid, mixed with a small quantity of soda-lime, is put into the remote end of the tube, occupying about an inch of the tube, and then about the same quantity of soda-lime. Then the nitrogenous substance, mixed with soda-lime, is introduced, filling about 8 inches of the tube. Then fill up about 4 inches of the tube with soda-lime, leaving two for insertion of a plug of asbestos and the cork for the attachment of the U-tube, to which some standard HCl is transferred with water sufficient to fill up to a certain height. Then the combustion tube is placed in the furnace and gradually heated, commencing at the end nearest the U-tube; and the remote end, containing the oxalic acid, is not heated until the evolution of gas has ceased. When it is heated, carbonic anhydride drives out before it all the ammonia remaining in the tube. The U-tube is removed, and the contained liquid is poured into an evaporating dish, and the bulb washed out several times. Platinic chloride is added, and it is evaporated to dryness, and digested with a mixture of alcohol and ether to remove excess of platinic chloride. The remaining double chloride of ammonia and platinum is weighed, when there will be 14 parts of nitrogen, taking 223 parts as the total weight, or 6·3 per cent. of the weight will be nitrogen; or the dried double salt is transferred to a crucible and heated to bright redness, when for 197·2 parts of platinum we allow 28 parts of nitrogen, or 14$\frac{1}{8}$th per cent. nearly. The ammonia method answers, except in cases where the nitrogen occurs in the form of nitric acid or cyanogen, when this element must be estimated by volume. This method is applicable in all cases. A combustion tube of about 32 inches long is taken, rounded like a test tube at one end. This tube is filled with some carbonate that, when heated, will give off carbonic anhydride, such as manganous carbonate, magnesite, or hydric sodic carbonate, and some mercuric oxide. A weighed portion of the substance for analysis, with upwards of forty times its weight of a mixture of oxide of copper and mercury, the rinsings of the mortar, a plug of asbestos, then about 4 inches of cupric oxide, asbestos, and a layer of about 8 inches of metallic copper. The end of the combustion tube is drawn out, and connected with a bent delivery tube, dipping beneath the mercury in the trough. When all is ready, the carbonate in the tube is heated to generate a current of carbonic anhydride to drive out all the air.

The metallic copper and copper oxide are heated simultaneously, and when the escaping gas is free from air, insert the end of the delivery tube through the tubulure of the vessel, and heat the portion of the tube containing the substance that is being analyzed, until all except the carbonate portion of the tube is at a bright red heat, and the evolution of gas has ceased, when the carbonate is heated to expel the last traces of the nitrogen gas. The delivery tube is withdrawn, and the gas is allowed to remain over a potash solution to absorb every trace of CO_2; after which the pure nitrogen is transferred to a measuring tube, from which the volume is determined from the data that 100 cubic inches of nitrogen at 15½° C., and at a pressure of 30 inches of mercury, weigh 30·15 grm., or a litre at 0° C., and 760 mm. weighs 1¼ grm.

The halogens, including bromine, chlorine, and iodine in organic compounds, are determined by mixing the substance containing them with about ten times its weight of caustic lime in a combustion tube, sealed at one end, and the remainder filled up with pure lime. The tube is closed with a cork, through which passes a short bent tube, dipping beneath some water in a vessel to prevent, by pressure, the escape of any of the halogens. Heat the tube until the water ceases bubbling. The contents of the tube are treated with pure nitric acid, and the liquid is filtered and treated with silver nitrate, which precipitates a silver salt of the halogen, which is washed, dried, and weighed, and from the weight of the salt the quantity of the halogen can be estimated.

Sulphur, arsenic, and phosphorus are determined by mixing potassic nitrate, sodic carbonate, and sodic chloride with the substance, and heating to redness in a combustion tube, when these elements are obtained as sulphate, arsenate, and phosphate. The sulphur forms sulphuric acid, which forms a salt with the alkali. Dissolve the residue in water, add HCl, then boil, and add $BaCl_2$, set aside for some time to form precipitate of baric sulphate, which, after several operations, is dried, ignited, and weighed, from which the quantity of sulphur can be estimated. When arsenic or phosphorus is present, it is determined by converting either into an ammonic magnesic arsenate or phosphate

---

ORGANIC SUBSTITUTION.

Substitution products are formed by the replacement of an element, radical, or group, in a compound by another element, radical, or group of elements.

A very important class of substitution products is obtained by replacing 1, 2, or 3 atoms of H in NH_3, by an organic radical. Thus we have the amines divided into monamines, diamines, triamines, and tetramines. The monamines are divided into primary, secondary, and tertiary. There are primary monamines of the methyl, vinyl, and phenyl series, having the general formula—$NH_2(C_nH_{2n+1})$, $NH_2(C_nH_{2n-1})$, and $NH_2(C_nH_{2n-7})$, in which one atom of the hydrogen in NH_3 has been replaced by the methyl, vinyl, or phenyl radical. Methylamine, $NH_2(CH_3)$; ethylamine, $NH_2(C_2H_5)$; butylamine, $NH_2(C_4H_9)$; amylamine, $NH_2(C_5H_{11})$, are primary monamines of the methyl series. Allylamine, $NH_2(C_3H_5)$, belongs to the vinyl series, and phenylamine, $NH_2(C_6H_5)$, and tolylamine, $NH_2(C_6H_4Me)$, to the phenyl series.

These may be formed by the action of potassic hydrate on the product formed by the action of the haloid compounds of the monad positive radicals on ammonia, thus—$NH_3 + EtI = NEtH_3I$ and $NEtH_3I + KHO = NH_2Et + OH_2 + KI$; or by treating cyanic ether with a boiling solution of KHO, thus: $CNEtO + 2KHO = NH_2Et + COKO_2$.

The secondary monamines of the methyl, vinyl, and *phenyl series, in* which two atoms of the hydrogen in

NH_3 are displaced by positive monad radicals of the methyl, vinyl, and phenyl series respectively. Dimethylamine, $NH(CH_3)_2$; diethylamine, $NH(C_2H_5)_2$; dibutylamine, $NH_4(C_4H_9)_2$; methylethylamine, $NH(CH_3)(C_2H_5)$; ethylamylamine, $NH(C_2H_5)(C_5H_{11})$, belong to the methyl series, and ethylphenylamine, $NH(C_2H_5)(C_6H_5)$, belongs partly to the methyl and phenyl series. Piperdine, $NH(C_5H_{10})''$, and conine, $NH(C_8H_{14})$, are also secondary monamines. They are produced by the action of KHO on the product formed by the haloid compounds of the monad positive radicals on the primary monamines, thus: $NH_2Me + MeI = NMe_2H_2I$, and $NMe_2H_2I + KHO = NHMe_2 + OH_2 + KI$. They may be formed containing two different radicals by using the iodide of a radical different to that contained in the primary monamine, thus: $NH_2(C_6H_5) + EtI = NH_2C_6H_5C_2H_5I$, and $NH_2C_6H_5C_2H_5I + KHO = NH(C_6H_5)(C_2H_5) + OH_2 + KI$.

In the tertiary monamines the three atoms of hydrogen in NH_3 are displaced by one, two, or three positive monad radicals; thus we have trimethylamine $N(CH_3)_3$, triethylamine $N(C_2H_5)_3$, tributylamine $N(C_4H_9)_3$, and triamylamine $N(C_5H_{11})_3$, in which the hydrogen is replaced by three of the same series of radicals, but in methylethyl phenylamine $N(CH_3)(C_2H_5)(C_6H_5)$ the hydrogen is replaced by different radicals.

Dimethylaniline $N(C_6H_5)Me_2$, dimethyltoluidine $N(C_6H_4Me)Me_2$, dimethylxylidine $N(C_6H_3Me_2)Me_2$, dimethylcumidine $N(C_6H_2Me_3)Me_2$, and dimethylcymidine $N(C_6HMe_4)Me_2$ are tertiary monamines, in which the radical C_6H_5 enters. These monamines are produced by acting on the secondary monamines with the iodides of the positive radicals and treating the product with KHO, thus: $NMe_2H + MeI = NMe_3HI$, and $NMe_3HI + KHO = NMe_3 + OH_2 + KI$. These tertiary monamines when acted on by the iodides of the monad positive radicals produce iodides that cannot be decomposed by KHO. A secondary monamine produces an iodide which becomes a tertiary monamine when acted on by KHO, and a primary monamine requires a further application of the iodide and KHO to produce the tertiary.

In the diamines the hydrogen of the two molecules of ammonia is displaced by a radical. In the primary diamines, one molecule of hydrogen is replaced, thus: $\left\{\begin{array}{l} NH_2 \\ Et'' \\ NH_2 \end{array}\right.$; in the secondary two molecules are displaced, thus: $\left\{\begin{array}{l} NH \\ Et_2 \\ NH \end{array}\right.$; and in the tertiary the three molecules are displaced, thus: $\left\{\begin{array}{l} NEt'' \\ Et' \\ NEt'' \end{array}\right.$.

Ethyl diamine $Et''(NH_2)_2$, ethylene diethyl diamine $Et''(NHEt)_2$, urea $CO(NH_2)_2$, ethyl urea $NHEtNH_2CO$, sulphur urea $CS(NH_2)_2$, and sulph phenyl urea $CSNHPhNH_2$, are well-known diamines.

The diamines are produced by acting on ammonia or primary or secondary monamines with a bromide of the diad radical, and decomposing the product by KHO.

The triamines contain three atoms of nitrogen, and the hydrogen of the three molecules of ammonia is replaced by various radicals. Rosaniline is one of the most important triamines. Its formula is $N_3(C_6H_4)''(C_7H_6)''_2H_3$, and perhaps it is formed by the abstraction of three molecules of hydrogen from one molecule of aniline and two of toluidine, thus: $2NH_2(C_7H_7) + NH_2(C_6H_5) = (NH_3)(C_7H_6)''_2(C_6H_4)'' + 3H_2$. By replacing one, two, or three of the atoms of H in rosaniline $N_3H_3(C_7H_6)''_2(C_6H_4)''$ by phenyl C_6H_5 we obtain phenyl rosaniline $N_3PhH_2(C_7H_6)''_2(C_6H_4)''$, diphenyl rosaniline $N_3Ph_2H(C_7H_6)''_2(C_6H_4)''$, and triphenyl rosaniline $N_3Ph_3(C_7H_6)''_2(C_6H_4)''$.

By replacing the H_3 by three of the tolyl radicals we obtain tritolyl rosaniline $N_3(C_7H_7)_3(C_7H_6)_2(C_6H_4)''$, and, by replacing by Et_3, we obtain triethyl rosaniline $N_3Et_3(C_7H_6)_2(C_6H_4)''$.

Chrysaniline $N_3C_{20}H_{17}$, and lake aniline $N_3C_{20}H_{21}$ are other triamines.

Rosaniline itself is prepared from toluidine and aniline *by arsenic acid* or other reagents.

There are also arsines, bismuthines, phosphines, and stibines, in which the hydrogen in AsH_3, BiH_3, PH_3, and SbH_3 is either partially or wholly replaced by radicals. Trimethyl arsine $AsMe_3$, triethyl arsine $AsEt_3$, triethyl bismuthine $BiEt_3$, methyl, dimethyl, and trimethyl phosphine $PMeH_2$, PMe_2H, and PMe_3, and ethyl, diethyl, and triethyl phosphine $PEtH_2$, PEt_2H, and PEt_3, and trimethyl, triethyl, and triamyl stibines $SbMe_3$, $SbEt_3$, and $SbAy_3$. From the above it may be observed that there are only tertiary compounds of arsenic, bismuth, and antimony, while the H in PH_8 may be replaced in the same manner as in NH_3, producing primary, secondary, and tertiary compounds.

The amides divided into the monamides, diamides, and triamides, so called because they are formed by the substitution of NH_2 amidogen (Ad) for the HO of the semimolecule of oxatyl $(COHO)_2$, or by the substitution of a monad positive radical with CO in the place of one, two, or three atoms of hydrogen.

Acetamide CH_3COAd or $NH_2(COMe)$, benzamide C_6H_5COAd or $NH_2(COPh)$, and chloracetamide $CH_2ClCOAd$ or $NH_2(COCH_2Cl)$ are primary monamides.

Diacetamide $NH(COMe)_2$ and $NH(COCH_2)_2$, are secondary monamides.

Oxamide, $C_2O_2(NH_2)_2$ or $(COAd)_2$, and succinamide, $Et(COAd)_2$ or $(NH_2)_2(C_4H_4O_2)''$, are primary diamides. The diamides may be regarded as formed by the substitution of $(NH_2)_2$ for the $(HO)_2$ in the semimolecule of $(COHO)_2$ in dibasic acids, or by the substitution of a diad negative radical for two atoms of H in two molecules of ammonia.

Citramide, $N_3H_6(C_6H_5O_4)'''$ or $C_3H_5O(COAd)_3$, is a triamide. The triamides may be regarded as formed by the substitution of the residue of a tribasic acid in place of three atoms of H, or by the substitution of NH_2 for HO in the three semimolecules of oxatyl.

The *alkalamides:—Ethyl* acetamide $NHEt(COMe)$, *ethyl diacetamide* $NEt(COMe)_2$, diethyl oxamide N_2H_2

$Et_2(CO)_2$, diphenyl oxatyl carbonyl diamide $N_2(C_6H_5)_2(CO)_2''(CO)''$, and citryl triphenyl triamide $NH_3(C_6H_5)_3(C_6H_5O_4)'''$, are derived from ammonia by the substitution of part of the hydrogen by positive, or a part by negative radicals. When the hydrogen in amines is replaced by bromine or chlorine, tribrominated and trichlorinated amines are formed—*e.g.*, $N(C_6H_2Cl_3)H_2$ trichloraniline. The imides have the general formula $NH(C_nH_{2n-1}O)_2$.

Succinimide, $NH(COCH_2)_2$ or $NH(C_4H_4O_2)''$, is formed by the substitution of a diad negative radical for two atoms of hydrogen in ammonia.

The nitrides have the general formula $N(C_nH_{2n-1}O)_3$, and may be obtained by the action of chloracids upon amides, thus: diacetimide $NH(COMe)_2 + COMeCl = N(COMe)_3 + HCl$. The organo-boron compounds are produced by the substitution of a monad positive radical for methoxyl, &c., thus: $BEtO_3$ becomes BMe_3 by the substitution of Me for EtO. The hydrides of the methyl series having the general formula C_nH_{2n+2}, form substitution compounds containing bromine, chlorine, &c.; thus we have CH_4, CH_3Cl, CH_2Cl_2, $CHCl_3$, and CCl_4, and C_2H_6, C_2H_5Cl, $C_2H_4Cl_2$, $C_2H_3Cl_3$, $C_2H_2Cl_4$, C_2HCl_5, and C_2Cl_6, &c., in which the hydrogen is replaced by chlorine.

In benzol or phenylic hydride, C_6H_6, we have C_6H_5Br, $C_6H_4Br_2$, $C_6H_3Br_3$, mono, di, and tribrom-benzol, the bromine displacing the hydrogen of the benzol. There are also similar chlorine substitution compounds, C_6H_5Cl, $C_6H_4Cl_2$, and $C_6H_3Cl_3$, the mono, di, and trichlorbenzol.

In nitrobenzol and dinitrobenzol, $C_6H_5(NO_2)$ and $C_6H_4(NO_2)_2$, the H is replaced by NO_2.

Orcin gives, with bromine, chlorine, and iodine, $C_7H_3Br_3HO_2$, $C_7H_3Cl_3HO_2$, and $C_7H_3I_3HO_2$.

Monobromorcin, $C_7H_5BrHO_2$, and trinitro orcinic acid, $C_7H_3(NO_2)_3HO_2$, are other compounds.

Carbolic acid, C_6H_5HO, gives the following substitution *products—viz.*, C_6H_4BrHO, $C_6H_3Cl_2HO$, $C_6H_2Cl_3HO$,

$C_6Cl_5HO, C_6H_4(NO_2)HO, C_6H_3(NO_2)_2HO, C_6H_2(NO_2)_3HO$, and $C_6H_2(NO_2)_2(NH_2)HO$.

By the substitution of oxatyl for hydrogen in C_6H_6, benzol, we obtain C_6H_5COHO, benzoic acid; $C_6H_4(COHO)_2$, phthalic acid; $C_6H_3(COHO)_3$, trimellitic acid; $C_6H_2(COHO)_4$, pyromellitic acid, and $C_6(COHO)_6$, mellitic acid. The haloid ethers are substitution products formed by replacing HO in the alcohols by bromine, chlorine, cyanogen, fluorine, or iodine. Thus there are MeCl, EtCl, EtI produced by replacing HO in MeHO, and EtHO by Cl and I; and $Et''Cy_2$ and $Et''Br_2$ by replacing HO_2 in $Et''HO_2$ by Cy_2 and Br_2.

Again we have $C_3H_5HO_2Cl$, $C_3H_5Cl_2HO$, and $C_3H_5Cl_3$ by replacing one, two, or three of HO in $C_nH_{2n-1}HO_3$ by Cl.

Methylenic and ethylenic iodides, CH_2I_2 and $C_2H_4I_2$; propylenic bromide, chloride, and iodide, $C_3H_6Br_2$, $C_3H_6Cl_2$, and $C_3H_6I_2$; butylenic bromide and chloride, $C_4H_8Br_2$ and $C_4H_8Cl_2$; and amylenic bromide and chloride, $C_5H_{10}Br_2$ and $C_5H_{10}Cl_2$; vinylic bromide, C_2H_3Br and C_3H_5OCl are other substitution products.

Chloral, CCl_3COH, is formed from CH_3COH by replacing H by Cl.

Chlorine converts the methyl series of acids into the chloro-substitution acids, thus: $CH_2(C_nH_{2n+1})COHO = CHCl(C_nH_{2n+1})COHO$.

The ketones are substitution products, formed by replacing the hydroxyl of the methyl series of acids by the monad positive radicals, thus: CH_3COHO becomes CH_3COMe, or $COMe_2$, when the HO of the acid is replaced by the radical CH_3 or Me. And by substituting a monad positive radical for the H of CH_3 in CH_3COMe we obtain $CMeH_2COMe$, methyl acetone, CMe_2HCOMe, $CEtH_2COMe$, $CPrH_2COMe$, and CEt_2HCOMe.

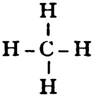
I have above referred to many of the substitution products that have been obtained. In fact substitution is one of the principal *methods* employed in the examination *of the composition of* organic bodies. The ordinary method of producing numerous inorganic compounds by double decomposition, is merely a substitution of one acid or one base for another. Speaking generally, organic substitution products are analogous in their properties to the compounds from which they are produced, the replacing element or group of elements merely supplying the place of the retiring elements, without disturbing the harmonious pre-existent relationship.

THE THEORY OF COMPOUND ORGANIC RADICALS.

Organic chemistry has been defined by Liebig as the chemistry of the compound radicals. To this general statement there are but few exceptions, for, as we shall see, compound radicals play a very important part in organic chemistry. There is scarcely a formula in which a compound radical does not appear. There are monad radicals of the methyl, vinyl, and phenyl series. There are diad radicals of the ethylene, acetylene, and phenylene series. There are also triad, &c., radicals. Cyanogen and oxatyl are termed negative radicals. I will now endeavour to explain what is meant by a radical. Radicals are simple or compound. The elements are simple radicals, and are monad, diad, triad, or polyad. Carbon is a tetrad element—*i.e.*, it is capable of uniting with 4 atoms of a monad element, such as chlorine or hydrogen, or two atoms of a diad element, like oxygen. A compound organic radical consists of a number of atoms, having one or more carbon atoms, of which one or more bonds are free to unite with other elements.

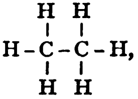
It is monad, diad, triad, &c., when one, two, three, &c., bonds are free or unsatisfied. Carbon being a tetrad element is capable of uniting with 4 atoms of hydrogen;

and it actually does so in the case of marsh-gas or methyl-hydride. Its formula is CH_4, and it is written

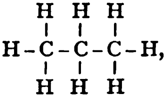


$$\begin{array}{ccccc} & & H & & \\ & & | & & \\ H & - & C & - & H \\ & & | & & \\ & & H & & \end{array}$$

graphically. As all the bonds are engaged it is termed a saturated compound, and cannot by any action or reaction be made to combine with another atom of hydrogen or chlorine. The following saturated compounds are known —viz. CH_4, C_2H_6, C_3H_8, C_4H_{10}, C_5H_{12}, C_6H_{14}, C_7H_{16}, C_8H_{18}, C_9H_{20}, $C_{10}H_{22}$, $C_{11}H_{24}$, $C_{12}H_{26}$, $C_{13}H_{28}$, $C_{14}H_{30}$, and $C_{15}H_{32}$. The first four are gases at the ordinary temperatures, those following are liquids, whose boiling points increase with the molecular weight, and those of the highest molecular weight are solid substances, called paraffin—hence the whole series is often termed the paraffin series.

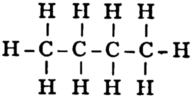


$$\begin{array}{ccccccc} & & H & & H & & \\ & & | & & | & & \\ H & - & C & - & C & - & H, \\ & & | & & | & & \\ & & H & & H & & \end{array}$$



$$\begin{array}{ccccccccc} & & H & & H & & H & & \\ & & | & & | & & | & & \\ H & - & C & - & C & - & C & - & H, \\ & & | & & | & & | & & \\ & & H & & H & & H & & \end{array}$$

and



$$\begin{array}{ccccccccccc} & & H & & H & & H & & H & & \\ & & | & & | & & | & & | & & \\ H & - & C & - & C & - & C & - & C & - & H \\ & & | & & | & & | & & | & & \\ & & H & & H & & H & & H & & \end{array}$$

are the graphic formulæ for C_2H_6, C_3H_8, and C_4H_{10}. Now, it will be observed that if any number of carbon atoms have all their bonds satisfied by a monad element, such as hydrogen, the end ones will be united with 3 atoms of hydrogen, and all the intermediate ones with only two. In the saturated paraffin series, CH_4, C_2H_6, C_3H_8, &c., if we leave one carbon bond unsatisfied, we shall have CH_3, C_2H_5, C_3H_7, &c., termed methyl, ethyl, propyl, &c., respectively; but, as these are monad radicals, they are incapable of existing in the free state, just as one atom of hydrogen is incapable of free existence. So we have the molecule of hydrogen, H_2, and the molecules of the above $(CH_3)_2$, $(C_2H_5)_2$, $(C_3H_7)_2$, &c. This series is represented *by the general formula,* C_nH_{2n+1}, and the corresponding alcohols by $C_nH_{2n+1}HO$; and we have the normal monohydric alcohols from CH_3HO to $C_{10}H_{21}HO$, and $C_{12}H_{25}HO$, $C_{16}H_{33}HO$, $C_{27}H_{55}HO$, and $C_{30}H_{61}HO$.

Again there are secondary and tertiary monohydric alcohols derived from these monad radicals, termed carbinols, the methylethyl, dimethylethyl, &c. The following aldehydes—viz., $HCOH$, CH_3COH, C_2H_5COH, C_3H_7COH, C_4H_9COH, $C_6H_{13}COH$, $C_9H_{19}COH$, $C_{10}H_{21}COH$, $C_{11}H_{23}COH$, and $C_{15}H_{31}COH$, derived from the $C_nH_{2n+1}HO$ series of alcohols, are known and contain the methyl series of compound radicals. The chlorides, CH_3Cl, C_2H_5Cl, C_3H_7Cl, C_4H_9Cl, $C_5H_{11}Cl$, $C_8H_{17}Cl$, $C_{16}H_{33}Cl$, have the same general radical, and there are also the iodides and bromides of the methyl radicals.

The ethers, OMe_2, $OMeEt$, OEt_2, $OMeAy$, $OEtBu$, $OEtAy$, OBu_2, OAy_2, contain the same series of radicals. The mercaptans, $MeHS$, $EtHS$, $BuHS$, $AyHS$, and $CyHS$, contain the same radicals. So do the sulphides, Me_2S, Et_2S, Ay_2S, and Cy_2S. The fatty or acetic series of acids contain the same radicals—viz., $HCOHO$, $MeCOHO$, $EtCOHO$, $PrCOHO$, $BuCOHO$, $AyCOHO$, $CpCOHO$, to $C_{29}H_{59}COHO$, melissic acid.

The vinyl or allyl series, having the general formula $(C_nH_{2n-1})_2$, of which allyl $(C_3H_5)_2$ is the most important, is contained in the alcohol C_3H_5HO, in C_3H_5Cl, C_3H_5I, C_3H_5Br; in allylic ether $(C_3H_5)_2O$; in allyl ethylic ether $(C_3H_5C_2H_5)O$, and other ethers; in the sulphide $(C_3H_5)_2S$; in the aldehyde C_2H_3COH; in allyl sulphuric acid $C_3H_5HSO_4$; in acrylic acid C_2H_3COHO, &c. The phenyl series having the general formula $(C_nH_{2n-7})_2$, of which the radicals phenyl $(C_6H_5)_2$ and benzyl $(C_7H_7)_2$ are the most important, are contained in phenylic alcohol or carbolic acid, C_6H_5HO, and benzylic alcohol, C_7H_7HO; in phenylic ether $(C_6H_5)_2O$, benzylic ether $(C_7H_7)_2O$, and phenyl-benzyl ether, $C_7H_7C_6H_5O$; in the aldehydes, C_6H_5COH and $C_9H_{11}COH$; the chloride, C_6H_5Cl; iodide, C_6H_5I; cyanide, C_6H_5CN; benzoic acid, C_6H_5COHo, &c.

Ethylene, C_2H_4, is a diad radical, because it can unite with two monad atoms, the saturated hydro-carbon being C_2H_6. The general formula is C_nH_{2n}, and it includes the following radicals—viz., ethylene (C_2H_4), propylene (C_3H_6), butylene (C_4H_8), amylene (C_5H_{10}), hexylene (C_6H_{12}), heptylene (C_7H_{14}), octylene (C_8H_{16}), nonylene (C_9H_{18}), paramylene ($C_{10}H_{20}$), cetene ($C_{16}H_{32}$), cerotine ($C_{27}H_{54}$), and melene ($C_{30}H_{60}$). The diad radicals of the whole series unite with chlorine, bromine, and iodine thus—$C_2H_4Cl_2$, $C_2H_4Br_2$, $C_2H_4I_2$, &c. There is the ethylenic or dihydric series of alcohols represented by the general formula, $C_nH_{2n}Ho_2$, ethylenic alcohol being $C_2H_4Ho_2$; the oxide, C_2H_4O; the ethylene diamine, $C_2H_4(NH_2)_2$; the cyanide, the mercaptan, C_2H_4HS, &c.

The acetylene series is the diad form of the vinyl-monad series of radicals, and is represented by the general formula C_nH_{2n-2}, and contains the radicals acetylene, C_2H_2; allylene, C_3H_4; crotomylene, C_4H_6; and valerylene, C_5H_8; and there is a chloride, bromide, nitride, and acetylide of copper, &c.

The phenylene, C_nH_{2n-8}, diad series of radicals contains the radicals phenylene, C_6H_4, and stilbene, C_7H_6, which are contained in $C_6H_4(COEt)_2$, &c. The triad radicals are represented in the trihydric alcohols, $C_3H_5Ho_3$ (glycerine), and $(C_3H_5)_2O_3$ ethers. There are also polyad radicals; and finally, there are negative radicals cyanogen, CN, and oxatyl $(COHO)_2$. The radical CN occurs in HCN, and in a numerous list of cyanides, &c.

The radical COHo exists in all organic acids. I do not presume to say that all these compound radicals do really exist. Many of them have been isolated, others have not, and perhaps never will be, but it is satisfactory to know that the radical in the compound containing the radical is generally preserved when new combinations are formed.

One example may be given to show the similarity between a compound organic radical and an inorganic monad element. The compound radical ethyl, C_2H_5, *represented by Et, is very* similar in its chemical behaviour to the metal, potassium. Ether, Et_2O; sulphuric ether, Et_2SO_4; hydro-sulphuric ether, Et_2S; hydrochloric ether, $EtCl$; nitric ether, $EtNO_3$; alcohol, $EtHO$; and mercaptan, $EtHS$, are exactly parallel with K_2O, K_2SO_4, K_2S, KCl, KNO_3, KHO, and KHS respectively. This, together with many other parallelisms, is sufficient to demonstrate that the compound organic radicals do exist and perform functions that are analogous to the monad, diad, triad, &c., elements of inorganic chemistry.

NOTATION OF ORGANIC COMPOUNDS.

In the notation of organic compounds carbon is made the dominant element in all non-nitrogenous compounds, and nitrogen dominant in all the compounds containing nitrogen. In the non-nitrogenous compounds the following typical forms of symbolic notation may be given—(1) CH_4, (2) $(CH_3)_2O$, and (3) C_2H_4.

In the nitrogenous we have (4) the NH_3 and (5) the NH_4Cl types of symbolic notation.

No. 1 may be taken as the type of the paraffin series, having the general formula, C_nH_{2n+2}.

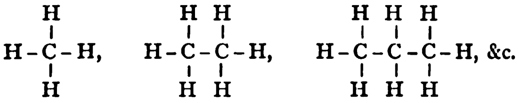
No. 2 may be taken as the type of the ethers, having the general formula $(C_nH_{2n+1})_2O$, of which $(CH_3)_2O$ is the first term.

No. 3 is the type of the ethylene series, having the general formula, C_nH_{2n}.

No. 4 is the type of the triad nitrogen and phosphorus; arsenic, antimony, and bismuth are analogues, as in the amines, amides, phosphines, arsines, stibines, bismuthines, &c.

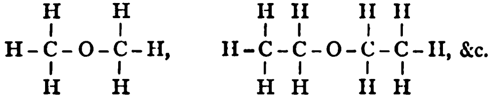
And No. 5 is the type of the pentad nitrogen and its analogues.

The graphic formulæ for the No. 1 series are—



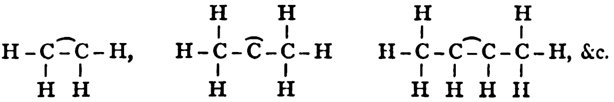
$$\begin{array}{ccccc} & & H & & \\ & & | & & \\ H & - & C & - & H, \\ & & | & & \\ & & H & & \end{array} \quad \begin{array}{ccccccc} & & H & & H & & \\ & & | & & | & & \\ H & - & C & - & C & - & H, \\ & & | & & | & & \\ & & H & & H & & \end{array} \quad \begin{array}{ccccccccc} & & H & & H & & H & & \\ & & | & & | & & | & & \\ H & - & C & - & C & - & C & - & H, \text{ \&c.} \\ & & | & & | & & | & & \\ & & H & & H & & H & & \end{array}$$

The graphic formulæ for the No. 2 series are—



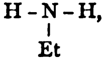
$$\begin{array}{ccccccccc} & & H & & & & H & & \\ & & | & & & & | & & \\ H & - & C & - & O & - & C & - & H, \\ & & | & & & & | & & \\ & & H & & & & H & & \end{array} \quad \begin{array}{ccccccccccccc} & & H & & H & & & & H & & H & & \\ & & | & & | & & & & | & & | & & \\ H & - & C & - & C & - & O & - & C & - & C & - & H, \text{ \&c.} \\ & & | & & | & & & & | & & | & & \\ & & H & & H & & & & H & & H & & \end{array}$$

The graphic formulæ for the No. 3 series are—



$$\begin{array}{ccccc} H & - & C\overset{\frown}{-}C & - & H, \\ & & |\quad | & & \\ & & H\quad H & & \end{array} \quad \begin{array}{ccccccccc} & & H & & & & H & & \\ & & | & & & & | & & \\ H & - & C & - & \overset{\frown}{C} & - & C & - & H \\ & & | & & & & | & & \\ & & H & & & & H & & \end{array} \quad \begin{array}{ccccccccccc} & & H & & & & & & H & & \\ & & | & & & & & & | & & \\ H & - & C & - & C & \overset{\frown}{-} & C & - & C & - & H, \text{ \&c.} \\ & & | & & | & & | & & | & & \\ & & H & & H & & H & & H & & \end{array}$$

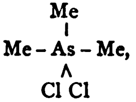
Ethylamine, $NEtH_2$, written graphically



$$\begin{array}{ccccc} H & - & N & - & H, \\ & & | & & \\ & & Et & & \end{array}$$

represents the No. 4 type.

And trimetho-dichloride, $AsMe_3Cl_2$, written graphically



$$\begin{array}{ccccc} & & Me & & \\ & & | & & \\ Me & - & As & - & Me, \\ & & \wedge & & \\ & & Cl\ Cl & & \end{array}$$

represents the No. 5 type.

PREPARATION AND PROPERTIES OF HYDRIDES OF ORGANIC RADICALS.

Methylhydride, methane, or marsh-gas (CH_4) is prepared by heating potassium or sodium acetate with soda-lime in a hard glass tube, or by heating sodium acetate with sodium hydrate in a metal retort. The soda-lime is prepared by slacking lime in a solution of caustic soda, and heating to drive off excess of water. The lime is added to prevent the caustic soda melting at the high temperature required for the decomposition, and so corroding the glass. It can also be prepared in a glass tube by mixing the sodium acetate and hydrate with quicklime. The reaction is as follows:—$CH_3CONaO + NaHo = CH_4 + CoNao_2$.

It can also be prepared synthetically from the elements carbon, hydrogen, and sulphur, for sulphur combines directly with carbon and hydrogen, forming carbon bisulphide and sulphuretted hydrogen. Carbon bisulphide is formed when carbon is heated to redness in an atmosphere of sulphur, and sulphuretted hydrogen is formed by passing a current of hydrogen through boiling sulphur.

The vapour of carbon bisulphide mixed with the sulphuretted hydrogen is passed over red-hot copper, when the following reaction takes place—viz. $2SH_2 + CS_2 + 8\,Cu = CH_4 + 4\,Cu_2S$.

It may be produced by decomposing zinc methide by water, thus: $ZnMe_2 + 2\,OH_2 = 2\,MeH + ZnHo_2$. It can also be obtained by reducing an alcoholic solution of chloroform and carbonic chloride by sodium amalgam and water, thus: $CHCl_3 + H_6 = CH_4 + 3\,HCl$; $CCl_4 + H_8 = CH_4 + 4\,HCl$. And by the destructive distillation of wood, coal, and other organic substances.

It is a gas without colour, odour, or taste, and the lightest substance known, except hydrogen, of which element it contains 25 per cent. It burns in the air with a scarcely visible flame, forming water and carbonic anhydride, and it requires twice its volume of oxygen for complete combustion, thus:—

$$CH_4 + 4O = CO_2 + 2OH_2.$$

If mixed in this proportion and lighted, a violent explosion takes place. It also explodes with air, but not quite so violently; however, on a large scale, as in mines, the explosion is terrific.

As it requires ten times its own volume of air for explosion, it leaves that volume of nitrogen and carbonic anhydride which cannot be respired. Methane is naturally abundant. It is continually disengaged in marshy districts, and from stagnant water covering organic matter. It is one of the gaseous products formed by the conversion of wood into coal. And as coal has been principally produced from wood, the quantity that has been formed in the conversion must be enormous. And it is the cause of the frequent explosions that occur in coal-mines. Nearly 90 per cent. of the occluded gas that coal just raised from the pit contains consists of this gas. Water dissolves about 5 per cent. of this gas, and it is slightly soluble in alcohol. It resists the action of the most powerful reagents. I have not yet heard of its liquefaction, but that is a foregone conclusion, since hydrogen has been liquefied. With chlorine it forms a series of substitution products in the daylight, as follows:—

$$CH_4 + Cl_2 = CH_3Cl + HCl:$$
$$CH_3Cl + Cl_2 = CH_2Cl_2 + HCl:$$
$$CH_2Cl_2 + Cl_2 = CHCl_3 + HCl:$$
$$CHCl_3 + Cl_2 = CCl_4 + HCl.$$

To prepare the radical methyl fill a strong tube with strips of zinc; and draw out at the top by the blow-pipe; then introduce methyl iodide by heating the tube and dipping the open end under the liquid iodide while cooling. Now exhaust the tube by an air-pump, and seal before the blow-pipe. By placing this tube for about two hours in an oil-bath at a temperature not higher than 150° C. the iodide is gradually decomposed—the sides of the tube are coated with a crystalline mixture of zinc iodide and methyl. A mixture has been formed of methyl and hydrocarbons liquefied by the pressure of their own vapours. When the sealed end of the tube is broken under water, the liquid escapes in the gaseous form; the methyl coming off last is collected in a nearly pure state.

It can also be obtained by decomposing potassic acetate

(CH_3CoKo), by a voltaic current, when it splits up into K and $C_2H_3O_2$, which decomposes immediately into CO_2 and CH_3; the K decomposes the water, giving off hydrogen, so that H is given off at the negative pole, and carbonic anhydride and methyl at the positive.

Methyl or ethyl hydride is a tasteless and odourless gas, burning with a scarcely luminous flame. It dissolves to some extent in alcohol, but not in water. From the formula $(CH_3)_2$ or C_2H_6 the molecular weight is 30, and it is, therefore, fifteen times as heavy as hydrogen, or a little heavier than air. When mixed with chlorine in the daylight, the two react as below:—

$$
\begin{aligned}
C_2H_6 + Cl_2 &= C_2H_5Cl + HCl: \\
C_2H_5Cl + Cl_2 &= C_2H_4Cl_2 + HCl: \\
C_2H_4Cl_2 + Cl_2 &= C_2H_3Cl_3 + HCl: \\
C_2H_3Cl_3 + Cl_2 &= C_2H_2Cl_4 + HCl: \\
C_2H_2Cl_4 + Cl_2 &= C_2HCl_5 + HCl: \\
C_2HCl_5 + Cl_2 &= C_2Cl_6 + HCl.
\end{aligned}
$$

Ethylic hydride is produced by acting on Zn ethide by water, thus: $Zn(C_2H_5)_2 + 2OH_2 = ZnHo_2 + 2\left\{\begin{matrix}C_2H_5\\ H\end{matrix}\right.$.

It can be prepared by decomposing equal parts of water and ethylic iodide by zinc in a sealed tube, at a temperature of about 160° C. for about two hours. When the sealed end of the tube is broken under water this gas escapes.

The reaction is $2C_2H_5I + 2Zn + OH_2 = ZnO + ZnI_2 + 2\left\{\begin{matrix}C_2H_5\\ H\end{matrix}\right.$.

Sodic ethide, acting on ethylic iodide, produces it thus: $C_2H_5Na + C_2H_5I = NaI + C_2H_4 + C_2H_6$.

By allowing cyanic ether to fall in drops on potassium in a flask having a vertical condenser and a bent tube for conveying the gas to be collected over water, potassic cyanide, cyanethine $(C_9H_{15}N_3)$, &c., are formed in the flask, while the hydride of ethyl is given off in the gaseous state. *The following* is the probable reaction—viz. $5C_2H_5CN$

$+ 2K = 2KCN + C_2H_4 + C_9H_{15}N_3 + EtH$. Methyl $\left\{\begin{matrix}CH_3\\CH_3\end{matrix}\right.$ and ethyl hydride $\left\{\begin{matrix}C_2H_5\\H\end{matrix}\right.$ are isomeric—*i.e.* both have 2 atoms of carbon combined with 6 of hydrogen (C_2H_6). They are identically one and the same substance. But there are many instances of isomerism in which the composition is identical, but the properties are dissimilar—*e.g.* formic ether, methyl acetate and propionic acid, represented by $C_3H_6O_2$, and ethylene oxide, acetic aldehyde, and vinic alcohol, represented by C_2H_4O.

Ethyl or butane may be produced by the action of the nascent oxygen, produced by the electrolysis on the oxatyl (CO Ho) of propionic acid $\left\{\begin{matrix}C_2H_5\\CO\,Ho\end{matrix}\right.$ converting it into carbonic anhydride and water, thus: $2C_2H_5COHo + O = (C_2H_5)_2 + OH_2 + 2CO_2$. It may be prepared from a mixture of ethyl iodide and granulated zinc sealed up in a strong glass tube from which the air has been exhausted. The manipulation is the same as that for the preparation of methyl which has already been described. It is heated for about two hours in an oil-bath at first to a temperature a little above 100° C., and after up to about 140° C. A white crystalline mixture of zinc iodide and zinc ethyl is deposited on the sides of the tube, while the ethyl, ethyline, and ethylic hydride form a fluid, having been liquefied by the pressure of their own vapours. After the heating process is complete the tube is cooled in a freezing mixture, and the tip broken off under water, when the ethyl hydride and ethylene come off, the first being more volatile than the ethyl, which is given off last, and is collected in a gas-holder.

It can also be prepared by exposing ethylic iodide and mercury to sunlight, thus: $Hg + 2EtI = Et_2 + HgI_2$.

Ethyl is a colourless gas about twice as heavy as air. It can be liquefied by a pressure of 2½ atmospheres at 3°·3 C., or it becomes fluid without pressure a few degrees below the freezing-point. It boils at − 23° C. It is insoluble *in water, but* alcohol dissolves nearly twenty *times its volume of this gas.*

Paraffin is obtained from tar, one of the products of the dry distillation of wood, bituminous coal, peat, Rangoon petroleum, and most animal and vegetable substances. The densest portion of the wood-tar oils is mixed by degrees with nearly half its weight of sulphuric acid. The temperature is raised to 100° C., and must not fall below 50° C. On standing, a colourless liquid forms on the surface, which, on cooling, becomes solid. When submitted to hydraulic pressure an oil is removed. It separates on standing after boiling with a solution of sodic hydrate, and on cooling becomes solid.

This crude paraffin is pressed several times, and repeatedly crystallized to separate from naphtha. It is melted, and steam blown through it, and treated with animal charcoal, after which it is a beautiful substance, and white as the best wax. It is now principally obtained from bituminous shale, which is much cheaper than coal, besides it can be more easily separated from the shale. There are upwards of 800,000 tons of shale distilled annually, yielding about 6000 tons of paraffin, and 24,000 gallons of crude oil, besides large quantities of lubricating oil and ammonic sulphate.

Paraffin is a white substance of ·87 specific gravity, without taste or smell, very similar in appearance to camphor and spermaceti. Spermaceti has a brighter lustre than paraffin, and camphor has about the same dull lustre, but can be easily distinguished by smell.

It is insoluble in water, and slightly soluble in boiling alcohol, but it freely dissolves in hot olive-oil, oil of turpentine, benzol, and ether. The strongest alkalies and acids have no effect on it. Chlorine does not act on it in the cold, but when passed into the melted paraffin HCl is produced. In this reaction it resembles the other hydrides of the monad radicals, the diad radicals uniting directly with chlorine. Thus C_2H_4, ethyline, a diad, unites with Cl, and forms $C_2H_4Cl_2$, but CH_4 unites with Cl, thus $CH_4 + Cl_2 = CH_3Cl + HCl$.

Paraffin can be mixed with bees'-wax, resin, spermaceti, and stearin, but not with camphor, pitch, or naphthalin.

It melts at 45° C., and burns with a smokeless flame. It is a very good electrical insulàtor. It is represented by the formula C_nH_{2n+2}. A definite value for n has not yet been determined.

Benzol may be prepared from coal-tar naphtha by exposing the tar to a temperature of 0° C., when it solidifies, leaving the naphtha in a fluid state. Faraday obtained it by subjecting butylene to a pressure of 30 atmospheres. It can be prepared by heating benzoic acid with excess of lime, thus: $\left\{\begin{matrix} C_6H_5 \\ CO\,Ho \end{matrix}\right. + Cao = CO\,Cao'' + C_6H_6$. By heating phthalic acid with lime, thus: $C_8H_6O_4 + 2Cao = 2CO\,Cao'' + C_6H_6$. By the dry distillation of quinic acid. By passing fat through tubes heated to redness. By heating the vapour of benzoic acid to redness, when it splits up thus: $C_6H_5CO\,Ho = C_6H_6 + CO_2$. By distilling calcic benzoate with lime a red liquid is produced, which, on redistillation, gives benzol. By distilling calcic benzoate with lime at a temperature of 320° C. benzophenone $C_6H_5C_7H_5O$ is produced, which is decomposed on being heated with lime and potassic hydrate into potassic benzoate and benzol. When the current of a powerful voltaic battery passes between two carbons in an atmosphere of hydrogen, acetylene C_2H_2 is formed, and benzol is obtained by strongly heating the acetylene.

Benzol is a colourless limpid liquid having a specific gravity of ·88, boiling at 81° C., and freezing at 0° C. in crystals like groups of fern leaves. It dissolves in ether, alcohol, methylic alcohol, and turpentine, but is insoluble in water. It dissolves fatty substances, gutta-percha, caoutchouc, camphor, and wax. When heated it dissolves iodine, phosphorus, and sulphur. Its symbol is C_6H_6 or Ph H (phenyl hydride), and 1 litre of the vapour weighs 39 criths.

Its graphic formula is written thus:—

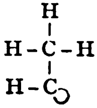
H - C = C - H

H - C   C - H

H - C - C - H

On boiling at 81° C. it gives off a gas which burns with a smoky flame. When acted on by nitric acid, bromine, chlorine, &c., it gives rise to many classes of compounds. Aniline is obtained from nitro-benzol, one of these compounds.

Ethylene may be prepared by passing the vapours of the haloid compounds of the normal monad radicals of the C_nH_{2n+1} series over heated lime, thus: $CH_3CH_2Cl = CH_2CH_2 + HCl$. By the transformation of the monad radicals at the moment of liberation from their compounds when they split into the hydrides of the monad radicals and the diad radicals, thus: $(C_2H_5)_2 = (CH_3)_2 + (CH_2)_2$. By the action of the sodium compound of a monad radical on the iodide, thus: $C_2H_5Na + C_2H_5I = NaI + (CH_3)_2 + C_2H_4$. Mix alcohol with four times its volume of concentrated sulphuric acid in a beaker and pour into a large flask half filled with sand to prevent frothing, and adapt the cork with exit tube, and heat in a sand-bath. Collect the gas over water in the ordinary way. If required pure, pass the gas through two wash bottles, one containing concentrated sulphuric acid, and the other sodic hydrate, which will absorb sulphurous and carbonic anhydride, ether, and alcohol vapour. Or take two flasks, one for alcohol, furnished with thistle funnel and exit tube, to connect with the other containing concentrated sulphuric acid, having thermometer inserted through cork with exit tube for giving off the gas over water. Both flasks are heated over gauze wire when the alcohol vapour passes to the flask containing the sulphuric acid heated up to about 160° C., when the alcohol is robbed of water, thus: $C_2H_6O - H_2O = C_2H_4$ or $C_2H_5Ho + SO_2Ho_2 = SO_2\ (C_2H_5H)\ O_2 + H_2o$ and $SO_2\ (C_2H_5H)\ O_2$ *splits up into* C_2H_4 and SO_2Ho_2. Ethylene is a colourless irrespirable gas, having a garlic odour. It burns with a bright white flame, and is the principal constituent of coal-gas. It requires three times its volume of oxygen for complete combustion, producing water and carbonic anhydride, thus: $C_2H_4 + 6O = 2OH_2 + 2CO_2$. Its molecular weight is 28, and one litre weighs 14 criths, which, multiplied by ·0693, gives ·97, its specific gravity in relation to air as unity. One litre weighs $14 \times ·0896 = 1·2544$ grm. It has been condensed to a thin mobile liquid at a temperature of $-110°$ C. under strong pressure. Water dissolves one-fourth of its volume of this gas at 0° C., and less than one-seventh at 20° C., so that it is more soluble in cold than in hot water. Ethylene and twice its volume of chlorine, when mixed and lighted, produces a cloud of black smoke, the chlorine combining with the hydrogen of the ethylene, thus: $4Cl + C_2H_4 = 4HCl + 2C$. When it is mixed with its own volume of Cl and exposed to the daylight, the two gases combine, producing Dutch liquid or ethylene dichlorine, thus: $C_2H_4 + 2Cl = C_2H_4Cl_2$. This is a colourless liquid, having the odour of chloroform. The diad radicals of the ethylene series all combine with Br Cl and I in this way. When it is continuously shaken with sulphuric acid it forms $C_2H_5HSO_4$, and if this is diluted with water and distilled, alcohol is obtained. If ethylene be digested with HI at 100° C. for about 50 hours, it forms ethylic iodide, thus: $(CH_2)_2 + HI = C_2H_5I$. When oxidized by potassic permanganate it forms formic acid, oxalic acid, water, and carbonic anhydride, thus: $C_2H_4 + O_5 = HCOHo + OH_2 + CO_2$ and $C_2H_4 + O_5 = (COHo)_2 + OH_2$. The graphic formula is written thus:—



$$\begin{array}{c} H \\ | \\ H-C-H \\ | \\ H-C\circlearrowleft \end{array}$$

Cyanogen, $(CN)_2$, *may* be easily obtained by heating *mercuric or argentic* cyanide, or a mixture of potassic cyanide and mercuric chloride. Or it may be prepared by heating ammonic oxalate, thus: $(CONH_4O)_2 = (CN)_2 + 4OH_2$.

The mercuric cyanide can be prepared by dissolving mercuric oxide in dilute hydrocyanic acid, and evaporating, when the mercuric cyanide crystallizes out in anhydrous rectangular prisms transparent and colourless. It can also be obtained by boiling one part of potassic ferrocyanide with two of mercuric sulphate. The powdered mercuric cyanide is heated in a small flask or tube, and the gas given off is collected in the ordinary way over mercury. A brown non-volatile substance remains in the tube having the formula C_nN_n, or perhaps C_6N_6, which has been termed paracyanogen. The carbon and nitrogen, of which cyanogen is composed, cannot be made to unite directly, but an alkaloid cyanide, such as KCN, can be made by passing a current of nitrogen over a heated mixture of potash and carbonaceous matter. Cyanic compounds are prepared on a large scale by heating feathers, hides, hoofs, and other nitrogenous organic matters with scrap iron and potassic carbonate. Lixiviate with water, and on crystallizing the soluble portion, potassic ferrocyanide, K_4FeCy_6, is obtained.

The other compounds of cyanogen are prepared by KCN and K_4FeCy_6. Cyanogen is a colourless poisonous gas, having a peach-like odour. It has a specific gravity of 1·8, and is liquefied by a pressure of 4·5 atmospheres, or by cooling to $-21°$ C., and by cooling to $-34°$ it freezes to a white solid. Water dissolves 4 or 5 volumes of this gas, and in alcohol it is still more soluble. It burns in air or oxygen with a splendid purple flame, forming carbonic anhydride and nitrogen.

Oxatyl, $(COHo)_2$, is oxalic acid divested of its two molecules of water, and constitutes dry oxalic acid. It is a radical which enters into the composition of nearly all organic acids in combination with hydrogen and other *radicals.* Acids containing COHo, a semimolecule of *oxatyl, are* monobasic—those containing two semimolecules, $(COHo)_2$, are dibasic, and those containing $(COHo)_3$, three semimolecules, are tribasic.

When cyanogen is dissolved in water ammonic oxalate is formed, thus: $(CN)_2 + 4OH_2 = (CONH_4o)_2$, and when ammonic oxalate is heated with phosphoric anhydride it loses water, and is converted into cyanogen, thus: $(CONH_4o)_2 = (CN)_2 + 4OH_2$.

Oxatyl, when treated with phosphoric chloride, produces carbonic anhydride, carbonic oxide, hydrochloric acid, and phosphoric oxychloride, thus: $(COHo)_2 + PCl_5 = CO_2 + CO + 2HCl + POCl_3$.

Oxalic acid, $(COHo)_2 + 2OH_2$, may be prepared by dissolving $(CN)_2$, cyanogen, in water, when ammonium oxalate is formed, and from this the molecule of oxatyl may be obtained by the action of sulphuric acid. Potassic hydrate and cyanogen give off ammonia and produce potassic oxalate, which may be changed into the acid by sulphuric acid. By the action of oxidizing agents nearly all organic substances are converted into oxalic acid before their final change into water and carbonic anhydride. By passing carbonic anhydride over heated sodium, sodic oxalate is formed, which can be converted into oxalic acid in the same way as potassic oxalate.

Mixing sawdust with a strong solution of sodic and potassic hydrates, and heating on iron plates when the wood is decomposed. When dry, the mass is treated with warm water, and the insoluble sodium oxalate is decomposed by boiling with milk of lime, and the calcic oxalate is decomposed by sulphuric acid, and the oxalic acid crystallized as $(COHo)_2 + 2OH_2$. Oxalic acid crystallizes in transparent colourless oblique rhombic prisms, having the composition $(COHo)_2 + 2OH_2$. When heated to 100° C. the crystals lose their two equivalents of water, and crumble into a white powder. It is soluble in water and alcohol. When the crystals are rapidly heated to 149° C. they are decomposed into water, carbonic oxide, and carbonic anhydride, formic acid being produced in the *process, and again* decomposed. When heated with strong sulphuric acid it is decomposed into carbonic oxide and anhyride, one equivalent of water uniting with the sulphuric acid. Oxidizing agents, such as potassic permanganate, binoxide of manganese, and a dilute acid, nitric acid, peroxide of lead, &c., convert oxalic acid into water and carbonic anhydride. Oxalic acid and its soluble salts are poisonous. When heated with an excess of alkali an oxalate yields hydrogen and a carbonate, thus:—$(COKo)_2 + 2KHo = H_2 + 2COKo_2$. It forms three series of salts—the normal, the acid, $\left\{\begin{matrix} COHo \\ COKo \end{matrix}\right.$ and the superacid $\left\{\begin{matrix} COHo \\ COKo \end{matrix}\right. \left\{\begin{matrix} COHo \\ COHo \end{matrix}\right.$. The oxalates of silver, lead, mercury, and barium are insoluble in water. Calcic oxalate is very insoluble in water, and potassic binoxalate is difficultly soluble in water, while potassic oxalate is soluble in water.

Oxalic acid is the first of a series of dibasic acids from $C_3H_4O_4$, malonic acid, to $C_{11}H_{20}O_4$, brassylic acid, and $C_{17}H_{32}O_4$, rocellic acid.

Oxamic acid is prepared by heating hydric ammonic oxalate to 230 °C., thus: $CONH_4oCOHo = CONH_2COHo + OH_2$, and by boiling with water it is transformed into hydric ammonic oxalate.

Oxamide is prepared by distilling ammonic oxalate, thus: $(CONH_4o)_2 = (CONH_2)_2 + 2OH_2$, or by acting on ethylic oxalate $(COEto)_2$ by ammonia, thus: $(COEto)_2 + 2NH_3 = (CONH_2)_2 + 2EtHo$. When an oxamide is heated with phosphoric anhydride it gives off cyanogen, thus: $(CONH_2)_2 = (CN)_2 + 2OH_2$. It is converted into oxalic acid by dilute acids, thus: $(CONH_2)_2 + H_2SO_4 + 2OH_2 = (NH_4)_2SO_4 + (COHo)_2$.

Calcic chloride, when added to solutions of oxalates, gives a white precipitate of calcic oxalate. Argentic nitrate gives, in oxalate solutions, a white precipitate of argentic oxalate, soluble in ammonia and nitric acid.

Hydrocyanic acid, HCN, is prepared by distilling potassic ferrocyanide (K_4FeCy_6) in a retort or flask with dilute sulphuric acid in the proportion of one of the former to four of the latter by weight. The retort or flask is connected with a Liebig's condenser and a receiver with a double neck, from which any uncondensed gas is carried to a Bunsen lamp and burnt. Care should be taken that the tube of the condenser dips into the water of the receiver, and that the joints are tight. The reaction is as follows:—$3H_2SO_4 + 2\,K_4FeCy_6 = 3K_2SO_4 + K_2Fe_2Cy_6 + 6HCN$. It is given off on the addition of dilute acid to potassic cyanide, thus: $H_2SO_4 + KCN = KHSO_4 + HCN$. It is produced by agitating silver cyanide with hydrochloric acid, thus: $HCl + AgCN = AgCl + HCN$. By mixing equal volumes of nitrogen and ethine and passing a series of induction sparks through the mixture, thus: $N_2 + C_2H_2 = 2HCN$. By heating ammonic formate, thus: $HCONH_4o = 2OH_2 + HCN$. By passing a stream of sulphuretted hydrogen over mercury cyanide, thus: $SH_2 + HgCN_2 = HgS + 2HCN$. The vapours are passed into a bent tube in a freezing mixture. By heating an alcoholic solution of ammonia, potassic hydrate, and chloroform together, thus: $NH_3 + 3KHo + CHCl_3 = 3OH_2 + 3KCl + HCN$. Hydrocyanic acid is very poisonous, and is produced from the kernels of bitter almonds, apricots, cherries, plums, and leaves of the cherry laurel and peach, and the blossoms of the mountain-ash and sloe. It also exists in the juice of many plants. It is derived from amygdalin in plants, which is fermented by emulsion, producing bitter almond oil, glucose, and hydrocyanic acid. It is a colourless liquid, having the odour of peach blossoms or oil of bitter almonds, boiling at 26°, freezing at $-15°$ into a crystalline mass. It has a specific gravity of ·7. When the liquid acid is allowed to volatilize rapidly the unevaporated portion solidifies. It can be mixed with water in all proportions. Its vapour burns in air, explodes when mixed with oxygen, and forms nitrogen, water, and carbonic anhydride. When the liquefied acid is warmed with hydrochloric acid solution, ammonic chloride and formic acid are produced, thus: $HCN + HCl + 2OH_2 = NH_4Cl + HCOHo$. It passes in contact with water into ammonic formate and oxalate. When the hydrogen of the acid is displaced by metals an extensive series of single and double cyanides are formed. Thus potassic cyanide is formed by heating it with potassium, the hydrogen being eliminated.

The solution of any cyanide with argentic nitrate gives a white precipitate of argentic cyanide insoluble in dilute nitric acid, but soluble in ammonic and potassic cyanide. When treated with potassic hydrate, it is converted into ammonia, potassic formate, and cyanide, thus: $2\ HCN + 2KHO\quad NH_3 + HCOKo + KCN$. If the vapours of dry hydrocyanic and hydrochloric acids be mixed at a low temperature, a crystalline odourless white substance is obtained having the formula CH_2NCl, and termed methenyl ammonic chloride. It decomposes in contact with air or water into formic acid and ammonic chloride. The alkaline cyanides are soluble in water, while the alkaline earthy cyanides are soluble with difficulty.

Mercuric cyanide is the only cyanide of a heavy metal that is soluble in water, but the cyanides of the heavy metals are soluble in a solution of potassic cyanide, forming double cyanides soluble in water. On igniting these double cyanides they are decomposed into the heavy metal and cyanogen, or carbon and nitrogen, but the alkaline cyanide is not decomposed, and can be dissolved from the residue. The cyanides of platinum, gold, cobalt, and iron are not decomposed by boiling with acids, but some of the others are readily decomposed with evolution of HCN.

Some double cyanides give off HCN when treated with dilute mineral acids, while others do not, thus: $K_2ZnCy_4 + 4HCl = ZnCl_2 + 2KCl + 4HCN$, and $K_4\,FeCy_6 + 4HCl = H_4FeCy_6 + 4KCl$. Hydrocyanic acid is easily detected by its odour of bitter almonds, and by its reactions with ammonic sulphide and the oxide of iron. To detect it in a solution distil with tartaric acid, and add potassic hydrate to the distillate, and a mixture of a ferrous and ferric salts, and finally HCl, when, if HCN is present, a precipitate of Prussian blue will be formed. Moisten a dish with a few drops of ammonic sulphide, and place it over the evolving HCN, when ammonic sulphocyanide is formed, which when washed off into a beaker, and acidulated with HCl, gives a blood-red solution on adding Fe_2Cl_6.

Formic acid, HCOHo, can be prepared by dissolving HCN in water, when it gradually changes into ammonic formate.

It can be obtained by heating together, at 100° C., carbonic oxide and potassic hydrate for two days, thus: $CO + KHo = HCOKo$. It is produced by the oxidation of organic substances, such as tartaric acid, woody fibre, starch, &c., by potassic hydrate, or by a mixture of sulphuric acid and manganic oxide. By distilling equal weights of oxalic acid and glycerine to 100° C., when the acid splits up into carbonic anhydride and formic acid, thus: $(COHo)_2 = HCOHo + CO_2$.

By the action of potassic hydrate on chloroform, thus: $KHo + CHCl_3 = 3KCl + 2OH_2 + COKo$. By oxidizing methylic alcohol, thus: $CH_3Ho + O_2 = HCOHo + OH_2$.

By heating hydrocyanic acid with an excess of an alcoholic solution of potassic hydrate, thus: $HCN + OH_2 + KHo = HCOKo + NH_3$. To obtain the anhydrous acid plumbic carbonate is added to dilute formic acid, and the solution crystallized. The resulting plumbic formiate is dried and decomposed in a retort with dry sulphuretted hydrogen when the anhydrous acid distils over, thus: $Pb\,(CHo_2)_2 + SH_2 = PbS + 2HCOHo$. It is a colourless fuming liquid having an irritating odour, boiling at 100° C. and freezing at 1° C. in brilliant scales. Its vapour burns with a blue flame. Its molecular weight is 46, and one litre of the vapour weighs 23 criths. Its specific gravity at 1° C. is 1·235. If dropped on the skin it produces painful sores. It is soluble in water and alcohol. It reduces the salts of gold, silver, platinum, and mercury at 100° C. and carbonic anhydride is given off. Sulphuric acid decomposes it, water and carbonic oxide being formed. When sodic formiate is heated, sodic oxalate is formed and hydrogen given off, thus: $(HCONao)_2 = (CONao)_2 + H_2$. Nitric acid converts it into water and carbonic anhydride, thus: $HCOHo + O = OH_2 + CO_2$. Chlorine decomposes it into carbonic anhydride and hydrochloric acid, thus: $HCOHo + Cl_2 = CO_2 + 2HCl$. Red ants when irritated eject this acid. It is found in the leaves of the stinging nettle, in the hairs of some caterpillars, and in the poison of the wasp and bee. It has been found in the blood, muscles, urine, &c. Some formiates are soluble in alcohol, but all are soluble in water. Formiates of the heavy metals when heated out of contact with the air give off water, carbonic oxide, and anhydride, leaving the metal; and alkaline formiates, when treated similarly, give off hydrogen and carbonic oxide, leaving a carbonate. When this acid is heated it is entirely volatilized. Ferric or calcic chlorides do not give any precipitate with formiates or the acid itself. Argentic or mercuric nitrate produce a white precipitate of the formiate of the metal in strong and neutral solutions of the formiates.

Prussian blue, $Fe_7Cy_{18} + 18H_2O$, is produced when a ferric salt and potassic ferrocyanide are mixed together, thus: $2Fe_2Cl_6 + 3K_4FeCy_6 = 12KCl + Fe_7Cy_{18}$. It may be prepared by mixing a solution of hydroferrocyanic acid with one of ferric chloride, thus: $3H_4FeCy_6 + 2Fe_2Cl_6 = 12HCl + Fe_7Cy_{18}$. It may be prepared by mixing solutions of ferric sulphate, $Fe_2S_3O_{12}$, and potassic ferrocyanide, thus: $2Fe_2S_3O_{12} + 3K_4FeCy_6 = Fe_7Cy_{18} + 6K_2SO_4$. The blue settles to the bottom of the vessel, is collected, dried, and obtained as a powder, or in cakes, according as it has been dried by exposure to the atmosphere or by applying heat. Prussian blue possesses neither taste nor smell. It is not soluble in dilute acids nor water. It is sold in cubical or irregular lumps of a dark blue colour. When rendered soluble by triturating with oxalic acid after washing in dilute HCl, it is dissolved in water forming a blue writing ink. Prussian blue is soluble in ammonic tartrate. Strong acids, chlorine, and the alkalies decompose it. The water contained in Prussian blue cannot be removed without breaking up the compound.

THE DISTILLATION OF COAL.

Bituminous coal, of which there are several varieties, is the best suited for the production of coal-gas. The Newcastle coal is principally used in the manufacture of London gas. Scotch parrot coal produces a superior gas, but the coke produced is of inferior quality. Boghead coal is also used for gas-making—in fact, every kind of coal except anthracite may be used for this purpose. The bituminous shale produces a very good gas, and it is used partly to supply the place of cannel or parrot coal. As carbon and hydrogen, principally with oxygen, are the elements from which gas is formed, most substances containing these elements can be partially converted into gas. And gas has been made from grease or kitchen waste, oil, peat, rosin, and wood, besides coal. A ton of Newcastle or caking coal yields about 9000 cubic feet of gas, Scotch coal about 11,000, English cannel about 10,000, and shale about 7000, with illuminating powers in the ratio of about 13, 25, 22, and 36 respectively. The coal is put in retorts *r*, Fig. 2, commonly made of fire-clay, and often of cast-iron. These retorts are from 6 ft. to 9 ft. long, and from 1 ft. to 1 ft. 8 in. in breadth. They are made like the letter D, elliptical, cylindrical, or bean-shaped. They are built into an arched oven, and heated by furnaces *f* beneath. One, three, five, seven, or more are built in the same oven. The mouth-pieces are of cast iron, and project outwards from the oven, so as to allow ascension pipes *a p* to be fixed, to convey the gas generated from the coal to the hydraulic main *h m*. After the coal has been introduced into the retorts, their mouths are closed with lids luted round the edges with clay, and kept tight by a screw. The retorts are kept at a bright red heat. If the temperature be too low less gas and more tar are produced, less residue being left; while should the temperature be too *high, the* product is more volatile, more *residue remaining*. And should the gas remain for any length of time in contact with the highly-heated retort, it

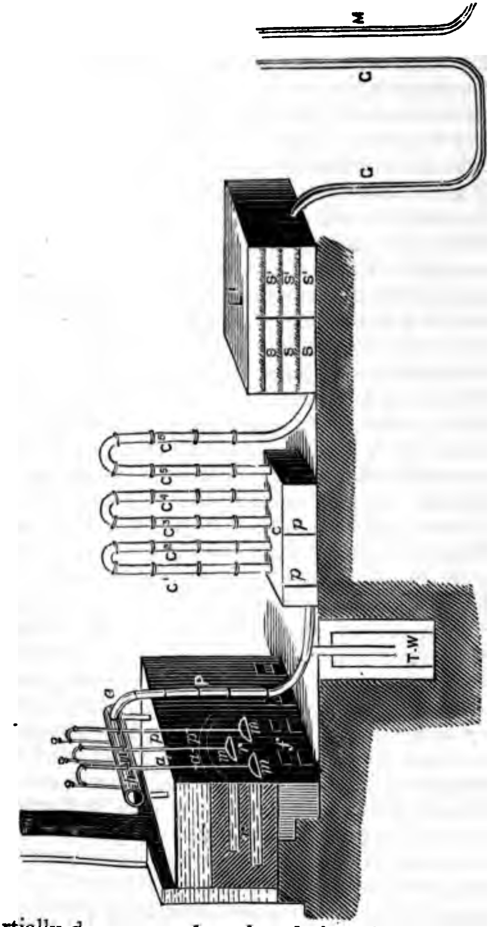


Fig 2.

is partially decomposed, carbon being deposited, there lessening the illuminating power, and choking up the retort, and more carbon disulphide is produced at a high temperature. The object is to maintain a medium temperature, in order to obtain a better gas having the greatest illuminating power. In about four or five hours the coal in the retort will have given off all its gas. The mouth of the retort is opened, and the coke is raked out into large iron vessels, and extinguished by water. A fresh charge is immediately introduced by means of a long scoop in the cherry-red retort, and the door luted to. The ascension pipes, which convey the gas from the retorts, pass straight up for a few feet, then turn round, forming an arch, then pass downwards into the hydraulic main, beneath the level of the liquid contained in it, and bubble up through the liquid into the upper portion of the main. On commencing the main is half filled with water, but after working some time, this water is displaced by the fluid products of distillation. In this way the opening into each retort is closed, so that a charge can be withdrawn and replaced without interfering with the action of the other retorts and pipes. The liquid tar, ammoniacal water, and gas pass from the end *e* of the hydraulic main, down through the pipe P, and the liquid falls down into the tar-well T W while the crude gas goes on into the chest C, partially filled with the liquid, so that the plates *p p* from the top dip into it to within a few inches of the bottom. These dip-plates are placed in the chest, so as to separate the openings into each pair of condensing pipes C C, so that the gas passing into the chest finds no exit, except up C^1, and down C^2, and there being no dip-plate between C^2 and C^3, it passes up C^3 and down C^4, and as there is no dip-plate to prevent its progress, it passes up C^5 and down C^6, into the lime or iron purifiers L^1. The condensers are kept cool by exposure to the atmosphere, and are often cooled by a stream of water from a tank above. The gas cools quickly, and liquids passing along with the gas in a state of vapour are condensed, and fall into the chest, and pass by an overflow pipe into the tar-well. The purifier is a cast-iron vessel L^1, containing a number of perforated shelves s^1 s^1 s^1, on which slaked lime, to the depth of about 4 in., or much greater thickness of iron oxide and sawdust, is placed. The gas passes up through the shelves s s s, and down through the shelves s^1 s^1 s^1, through the pipe G, into the gasholder, and from thence through the pipe M, to the main-pipe. The lime abstracts carbonic anhydride, sulphuretted hydrogen, cyanogen, naphthalin, and a portion of the ammonia, but not carbon disulphide, which latter may be absorbed by passing the gas through a solution of sodic hydrate and plumbic oxide, mixed with sawdust. Gas containing CS_2, on burning produces H_2SO_4, which injures books and furniture in rooms. However, the quantity of CS_2 in gas is generally so minute as to be practically uninjurious. By a proper regulation of the temperature during distillation, the quantity produced is infinitesimal. When the lime is saturated it is removed, and fresh supplied; but the iron after use can be reconverted into oxide by exposure to the atmosphere, and used repeatedly. When iron is used a separate lime purifier is necessary to remove carbonic anhydride. The last traces of ammonia are removed before passing to the gasholder, by passing the gas through dilute sulphuric acid, or up through the interior of a tower having perforated shelves covered with coke in small pieces, through which a constant supply of fresh-water percolates. This washing removes some of the more condensible hydrocarbons, and lessens the illuminating power of the gas. Before the gas passes from the condensers into the purifiers, it passes through a kind of pump, termed an exhauster, driven by steam power. This action relieves the retorts from the pressure of the gas passing through the hydraulic main, &c. It diminishes the deposit of graphite in the retorts, and lessens leakage in them, should there be any flaws. It also has the beneficial effect of producing a gas of a higher illuminating power, since the relief of pressure in the retorts produces a more favourable condition of combustion. The following are some of the bodies produced in the manufacture of gas—viz., acetylene (*g*), the carbonate (*s*), chloride (*s*), cyanide (*s*), sulphide (*s*), and sulphate (*s*) of ammonium; aniline (*l*), anthracene (*s*), benzine (*l*), carbonic oxide (*g*), carbonic anhydride (*g*), carbonic disulphide (*l*), chrysene (*s*), cumene (*l*), cymene (*l*), ethylene (*g*), hydrogen (*g*), leucoline (*l*), methyl-hydride (*g*), naphthaline (*s*), nitrogen (*g*), paraffin (*s*), phenylic alcohol (*l*), picoline (*l*), propene (*g*), quartene (*g*), sulphuretted hydrogen (*g*), toluene (*l*), water (*l*), xylene (*l*), &c. The most of the above solid and liquid substances, with the letters *s* and *l* written after, are removed by cooling the gas in the condensers, and the gaseous substances marked (*g*), that are injurious in the consumption of the gas, are removed by purification. The impurities in the gas may consist of ammonic carbonate and sulphide, carbonic anhydride and disulphide, nitrogen, oxygen, sulphuretted hydrogen, and water in the form of vapour; and acetylene, ethylene, and the vapours of the acetylene, ethylene, and phenylene series of hydrocarbons are the illuminating ingredients diluted with carbonic oxide, hydrogen, and methyl-hydride. The approximate percentage composition of coal-gas is—H, 45·6; Me, 34·8; CO, 6·5; C_2H_4, 4; CO_2, 3·6; N, 2·4; C_4H_8, 2·3; SH_2, ·3; &c.

ALCOHOLS.

The term alcohol was originally applied to the spirituous liquor produced by the fermentation of sugar, thus: $C_6H_{12}O_6 = 2CO_2 + 2C_2H_5Ho$. From the formula C_2H_5Ho we see that it is a compound of the hydrocarbon ethyl, C_2H_5, and a semimolecule of hydroxyl, H_2O_2; and as the other hydrocarbons of the series having the general formula, $C_n H_{2n+1}$, to which C_2H_5, ethyl, belongs, unite with hydroxyl, forming homologous compounds possessing chemical properties analogous to this substance, the term alcohol has been made generic, and has therefore been applied to the whole class of substances. This term has been still further extended to all neutral compounds of carbon, hydrogen, and oxygen, which produce ether by the abstraction of water by acids from these compounds. The alcohols may be supposed to be derived from water by the substitution of radicals of the series C_nH_{2n+1} for one atom of hydrogen, thus: $O\left\{\begin{matrix}H\\H\end{matrix}\right.$ and $O\left\{\begin{matrix}C_2H_5\\H\end{matrix}\right.$.

Methyl alcohol is one of the products obtained from the destructive distillation of wood in closed vessels. It is obtained from methosalicylic acid by the action of potassic hydrate, thus: $C_7H_4OMeOHo + KHo = CH_3Ho + C_7H_4OKOHO$.

By the action of potassic hydrate on methylic chloride, which is obtained by the action of chlorine on marsh-gas, thus:

$$CH_4 + Cl_2 = HCl + CH_3Cl, \text{ and}$$
$$CH_3Cl + KHo = KCl + CH_3Ho.$$

When distilled from wood it is accompanied with acetic acid, methyl and ammonic acetates, hydrocarbons, and tarry matter. This mixture of substances is saturated with lime and distilled. The lime retains the acetic acid, tarry matter, and water, and the methyl alcohol and other substances distil over. After another distillation with lime dry calcic chloride is added to the distillate, which combines with the methyl alcohol. The other substances can be driven off by heating to 100°C. The dry mass that is left is mixed with water and distilled, when this alcohol distils over and is dried by redistillation with quicklime.

Methyl alcohol is an inflammable colourless liquid, having an odour somewhat like ordinary alcohol, and a burning taste. It has a specific gravity of ·8 and boils at 66° C. Its molecular weight is 32, and one litre of the vapour weighs 16 criths. Water, alcohol, and ether dissolve it in all proportions. It burns like common alcohol, producing water and carbonic anhydride. It is generally used as a substitute for ordinary alcohol on account of its cheapness, and these two are mixed and sold as methylated spirit. It dissolves fats, essential oils, and resins. The resin solution is used as varnish. This alcohol unites with calcic chloride, forming crystals, having the composition $2MeHoCaCl_2$, and it dissolves baryta, forming the crystal compound $2MeHoBao$. It dissolves sodic and potassic hydrates, and when oxidized water and formic acid are formed, thus: $CH_3Ho + O_2 = OH_2 + HCOHo$. Sodium and potassium displace one atom of hydrogen, forming the methylates CH_3Nao and CH_3Ko. When heated with potassic hydrate hydrogen is given off, and potassic oxalate is formed, thus: $2CH_3Ho + 2KHo = (COKo)_2 + 5H_2$. Chloroform is produced when it is distilled with bleaching powder and water, thus: $2CH_3HO + 4CaoCl_2 = 3OH_2 + (Cao)_2O(CaCl)_2 + 2CHCl_3$. Hydrochloric acid acts on it, forming water and methylchloride, thus: $CH_3Ho + HCl = OH_2 + CH_3Cl$. Similar compounds can be formed by the action of HBr and HI. It forms CH_3HSO_4 and $(CH_3)_2SO_4$ with H_2SO_4. When it is distilled with CH_3HSO_4, methyl ether is formed, which is isomeric with ethyl alcohol, thus: $CH_3HSO_4 + CH_3HO = H_2SO_4 + (CH_3)_2O$.

Ethylic alcohol is prepared by the action of HI on CH_3Ho, giving methyl iodide, thus: $CH_3Ho + HI = OH_2 + CH_3I$, and by the action of zinc on the iodide ethyl hydride is obtained, thus: $2CH_3I + Zn = C_2H_6 + ZnI_2$, and by the action of chlorine on this hydride ethyl chloride is obtained, thus: $C_2H_6 + Cl_2 = C_2H_5Cl + HCl$. By acting on this chloride by potassic hydrate the alcohol is obtained, thus: $C_2H_5Cl + KHo = C_2H_5Ho + KCl$.

Acetylene, C_2H_2, is produced by the voltaic current passing between carbon points in an atmosphere of hydrogen, and nascent hydrogen acting on C_2H_2 forms C_2H_4, and H_2SO_4 with this forms $HC_2H_5SO_4$, which, being distilled with water, forms alcohol, thus: $HC_2H_5SO_4 + OH_2 = H_2SO_4 + C_2H_5Ho$. By adding one part of fresh beer yeast to four parts of cane-sugar dissolved in twenty *parts of water, fermentation* will commence in less than an hour at a temperature of about 30° C. The cane-sugar takes up water and forms grape-sugar, thus: $C_{12}H_{22}O_{11} + OH_2 = 2C_6H_{12}O_6$, and the yeast acting on the grape-sugar forms carbonic anhydride and alcohol, thus: $C_6H_{12}O_6 = 2CO_2 + 2C_2H_5Ho$. The fermented liquid is distilled, by which the crude alcohol is obtained containing water and small quantities of other substances. This crude spirit is poured on fragments of quicklime in a retort and allowed to stand until the lime falls to powder, by abstracting water from the alcohol and forming calcic hydrate. It is distilled in a water or calcic chloride bath, the result being absolute or anhydrous alcohol. However, if it still contains traces of water, subject it to another distillation with quicklime.

Ethylic alcohol is a volatile, inflammable, limpid, colourless liquid, with an agreeable odour and a hot burning taste. It boils at 78·5° C., and has not been solidified, but at – 110° C. it becomes glutinous. For this reason it is used, when coloured by cochineal, to register low temperatures. Its molecular weight is 46, and one litre of the vapour weighs 23 criths. Its specific gravity is ·81 at 0° C., and in the state of vapour it is 1·6. It burns with a non-luminous flame, forming water and carbonic anhydride, requiring 3 volumes of oxygen for perfect combustion, thus: $C_2H_5Ho + 6O = 2CO_2 + 3OH_2$. As it burns at a high temperature and deposits no soot on bodies introduced into its flame, it furnishes a very valuable source of heat to chemists. It forms the characteristic ingredient of fermented liquors, of which an extraordinary quantity is consumed to produce a state of temporary insanity and curtail the natural length of life. It is a narcotic poison, and when taken in excess in the concentrated state causes death. It is one of the most important medicines and one of the most important chemical reagents. Proof spirit contains approximately equal weights of alcohol and water, exactly = 50·76 of the former and 49·24 of the latter, and having a specific gravity of ·91984 at 60° F. Whisky and brandy should contain upwards of 50 per cent. of alcohol. Wines contain from 17 to 7 per cent., and beer, ale, and porter from 5 to 7 per cent. by weight of alcohol. It is difficult to obtain absolute alcohol on account of its strong affinity for water. When mixed with water it emits heat and contracts in volume, 50 volumes of water and 53½ of alcohol producing 100 instead of 103½ volumes of the mixture. Alcohol dissolves a great many substances, and, being volatile, can easily be separated, leaving the substance dissolved in a pure state. It dissolves many of the vegetable acids, most of the deliquescent salts, many of the gases, the hydrocarbons, the essential oils, the vegetable alkaloids, the resins, K, Na, KHo, NaHo, K_2S, Na_2S, NH_3, Br, I, CO_2, ON_2, $(CN)_2$, PH_3, and small quantities of S, P, soaps, sugar, fats, and fixed oils. It is decomposed when passed through hot tubes, the products varying according to the temperature. At a very high temperature hydrogen alone is given off and carbon deposited, at a lower temperature naphthalin and benzol, and at a still lower temperature carbonic oxide, marsh-gas, olefiant gas, water, ethylene, acetylene, and hydrogen are produced. By oxidation it is converted first into aldehyde and afterwards into acetic acid, thus: $C_2H_5Ho + O = MeCOH + OH_2$ and $CH_3COH + O = CH_3COHo$. When poured on sodium or potassium ethylates are formed, hydrogen being given off, thus: C_2H_5Nao and C_2H_5Ko. When treated with nitric acid; oxalic, glycolic, and glyoxalic acids and nitrous ether are produced. When one part by weight of silver is dissolved in two parts of NO_2Ho and excess of alcohol added, crystals of argentic fulminate are formed. When treated with chlorine; hydrochloric acid, ethylic chloride, and chloral hydrate are produced, thus: $2C_2H_5Ho + 4Cl_2 = 4HCl + C_2H_5Cl + C_2H_2Cl_3O_2$. Chloroform is produced when it is distilled with chloride of lime. Alcohol takes the place of water of crystallization in the following compounds termed alcoholates, viz., $CaCl_24C_2H_5Ho$, $ZnCl_2 2C_2H_5Ho$, $N_2O_4Cao6C_2H_5Ho$, $N_2O_4Mgo6C_2H_5Ho$, and $MnCl_24C_2H_5Ho$.

Phenylic alcohol or carbolic acid is formed by passing ethylic alcohol through a red-hot tube and by passing acetic acid through a red-hot tube. It is produced by treating aniline hydrochlorate with potassic nitrate, thus: $NH_2C_6H_5HCl + NOKo = C_6H_5Ho + N_2 + OH_2 + KCl$. It is obtained by distilling salicylic acid with lime, thus: $C_6H_4HOCOHo + Cao = C_6H_5Ho + COCao''$. It is produced by the destructive distillation of many organic bodies, especially of coal. The oil of the coal-tar, which boils between 150° and 200° C., is collected and mixed with a hot saturated solution of potassic or sodic hydrate, and when some powdered hydrate is added a white precipitate is formed. The precipitate is dissolved in some water, when the solution of potassic or sodic phenate will fall to the bottom of the vessel, while a lighter layer of oil remains on the top, which is separated, and the potassic or sodic phenate is decomposed by HCl, when the phenylic alcohol is liberated and rises to the top. To remove water it is digested with calcic chloride. It is distilled, when it crystallizes in colourless needles on being exposed to a gradually diminishing temperature. It is produced by the distillation of gum benzoin, which contains benzoic acid, C_6H_5COHo, from which C_6H_5Ho is obtained. This gum also contains an essential oil and three varieties of resin. The *Xanthorrhoea hastilis*, the grass-tree of New South Wales, yields a yellow gummy substance, from which this alcohol is obtained by distillation.

Phenylic alcohol or carbolic acid, when pure, is a white crystalline solid, melting at about 35° C., and boiling at 187° C. Its molecular weight is 94, and one litre of the vapour weighs 47 criths. It is benzol, C_6H_6, in which one atom of H has been replaced by HO. It does not, like the true alcohols, give an acid on oxidation, but the H of the HO is displaced by the metals in the same way as acids, so that this substance possesses at once the nature both of alcohols and acids. Picric or trinitrophenylic acid, $C_6H_2(NO_2)_3Ho$, like any acid, forms salts that crystallize well. It has the odour of tar or creosote, and has a hot taste. It is much used as a disinfectant, rendering sewage, &c., inoffensive, It quickly arrests all fermentative and putrefactive changes. It readily dissolves in ether, strong acetic acid, and alcohol, but is scarcely soluble in water. Its crystals readily liquefy in presence of moisture; with water it forms a crystalline hydrate, $(C_6H_5Ho)2H_2O$. Treated with Br it forms C_6H_4BrHo. Treated with chlorine it forms the substitutive products, $C_6H_3Cl_2Ho$, $C_6H_2Cl_3Ho$, and C_6Cl_5Ho. Treated with nitric acid it forms $C_6H_4(NO_2)Ho$, $C_6H_3(No_2)_2Ho$, and $C_6H_2(NO_2)_3Ho$. It forms with plumbic oxide an insoluble compound, C_6H_5HoPbo. The dye termed aurine is formed by mixing it with H_2SO_4 in a glass vessel and heating to 127° C., when a quantity of oxalic acid, nearly equal to the weight of H_2SO_4, is gradually added. When put in cold water it solidifies in a green mass, which is next worked in boiling water to remove some of the H_2SO_4. It forms, with potash and soda, crystalline compounds. When put in a sealed tube with ammonia and heated, aniline, $N\ (C_6H_5)H_2$, is formed, thus: $C_6H_5Ho + NH_3 = N\ (C_6H_5)H_2 + OH_2$.

THE ETHERS.

The ethers may be divided into the ethers of the monohydric, dihydric, and trihydric alcohols. The ethers of the monohydric, dihydric, and trihydric alcohols bear the same relation to the corresponding alcohols as the metallic oxides bear to the metallic hydrates.

The ethers of the monohydric alcohols are represented by the general formulæ $(C_nH_{2n+1})_2O$, $(C_nH_{2n-1})_2O$, and $(C_nH_{2n-7})_2O$, the methyl, vinyl, and phenyl series respectively. The ethers of the dihydric alcohols, represented by the general formula $C_nH_{2n}O$, the ethylene series. The ethers of the trihydric alcohols, represented by the general formula

$$\left\{\begin{matrix}(C_nH_{2n})_2O\\(C_nH_{2n-1})_2O\\(C_nH_{2n})_2O\end{matrix}\right.\cdot$$

The alcohols and ethers may be regarded as formed on the type of water, thus: $\left.\begin{matrix}H\\H\end{matrix}\right\}O$ $\left.\begin{matrix}CH_3\\H\end{matrix}\right\}O$, methylic alcohol, and $\left.\begin{matrix}CH_3\\CH_3\end{matrix}\right\}O$, methylic ether.

In the case of the alcohols one atom of hydrogen is displaced by the monad positive radical, while in the ethers both are displaced. The ethers of the monohydric alcohols are formed by substituting a positive monad radical in place of the hydrogen of the hydroxyl, thus: $\left.\begin{matrix}C_2H_5\\H\end{matrix}\right\}O$ is ethylic alcohol, and $\left.\begin{matrix}C_2H_5\\C_2H_5\end{matrix}\right\}O$ is ethylic ether, formed by substituting C_2H_5, the positive monad radical ethyl, instead of the atom of H in the HO.

Sometimes a different monad positive radical from that contained in the alcohol is substituted instead of the hydrogen of the hydroxyl, thus: $\left.\begin{matrix}CH_3\\H\end{matrix}\right\}O$, methylic alcohol, becomes $\left.\begin{matrix}CH_3\\C_2H_5\end{matrix}\right\}O$, methylic ethylic ether, by substituting C_2H_5 in place of the H of the HO of the methylic alcohol. This is termed a mixed ether.

These ethers are formed by distilling the alcohols of the series $C_nH_{2n+1}HO$ with H_2SO_4 in two stages, thus: $C_nH_{2n+1}HO + H_2SO_4 = HC_nH_{2n+1}SO_4 + OH_2$ and $HC_nH_{2n+1}SO_4 + C_nH_{2n+1}HO = (C_nH_{2n+1})_2O + H_2SO_4$.

These ethers can be converted again into the corresponding alcohols by treatment with H_2SO_4 and distilling the sulpho-acid with water, thus: $(C_nH_{2n+1})_2O + 2H_2SO_4 = 2HC_nH_{2n+1}SO_4 + OH_2$ and $HC_nH_{2n+1}SO_4 + OH_2 = C_nH_{2n+1}HO + H_2SO_4$.

The methyl series contains the following ethers, viz., methylic ether $(CH_3)_2O$, ethylic ether $(C_2H_5)_2O$, butyric ether $(C_4H_9)_2O$, amylic ether $(C_5H_{11})_2O$, methyl-ethylic ether $CH_3C_2H_5O$, methyl-amylic ether $CH_3C_5H_{11}O$, *ethyl-butylic* ether $C_2H_5C_4H_9O$, ethyl-amylic ether $C_2H_5C_5H_{11}O$, &c.

Of the vinyl series only allylic ether $(C_3H_5)_2O$ is known.

In the phenyl series we have phenylic ether $(C_6H_5)_2O$, and benzylic ether $(C_7H_7)_2O$.

There are three ethers of the dihydric alcohols, viz., ethylene oxide C_2H_4O, propylenic oxide C_3H_6O, and amylenic oxide $C_5H_{10}O$. Of the trihydric alcohols only glycylic ether

$$\left\{\begin{matrix}(CH_2)_2O\\ (CH)_2O\\ (CH_2)_2O\end{matrix}\right. \text{ is known.}$$

Ethylic ether is prepared by heating a mixture of sulphuric acid and ethylic alcohol in a flask provided with a thermometer to a temperature of about 140° C. A continuous supply of alcohol is maintained through a funnel into the flask, the H_2SO_4 acting apparently by its presence only, so that the same acid is capable of converting a large quantity of alcohol into ether.

Water and ether distil over into a bottle in two layers, the water below and the ether above. To purify the ether from alcohol and other impurities it is agitated with dilute sodic hydrate.

The alkali neutralizes any sulphurous acid that may be present while the water combines with the alcohol. The upper layer of the liquid then consists of ether with a little water, which may be separated by allowing it to stand a day or two upon quicklime. It is then distilled in a water bath, and condensed in vessels surrounded by water at 0° C.

There are two stages in the reaction: (1) the conversion of the sulphuric acid into ethyl, sulphuric, or sulphovinic acid, and (2) the decomposition of a fresh supply of alcohol into ether by this sulphovinic acid, thus:—

$$(1)\ \left.\begin{matrix}\mathrm{Et}\\ \mathrm{H}\end{matrix}\right\}\mathrm{O}+\left.\begin{matrix}\mathrm{H}\\ \mathrm{H}\end{matrix}\right\}\mathrm{SO_4}=\left.\begin{matrix}\mathrm{Et}\\ \mathrm{H}\end{matrix}\right\}\mathrm{SO_4}+\mathrm{OH_2}.$$

$$(2)\ \left.\begin{matrix}Et\\ H\end{matrix}\right\}SO_4+\left.\begin{matrix}Et\\ H\end{matrix}\right\}O=\left.\begin{matrix}\mathrm{C_2H_5}\\ \mathrm{C_2H_5}\end{matrix}\right\}\mathrm{O}\text{ or }\left.\begin{matrix}\mathrm{Et}\\ \mathrm{Et}\end{matrix}\right\}\mathrm{O}+\mathrm{H_2SO_4}.$$

If, as it has been supposed, ether is formed by the abstraction of water from two molecules of alcohol by the sulphuric acid, the acid would become more dilute; but this is not the case. Moreover, if the sulphovinic acid, instead of being acted upon by ethylic alcohol, is acted upon by amylic alcohol, ethyl-amylic ether is formed, and not ethylic and amylic ethers separately, which would occur if the sulphuric acid simply acted by abstracting water. This ether is a transparent, colourless, mobile, volatile fluid, has a powerful and peculiar odour, and a hot taste. Its molecular weight is 74, and one litre of the vapour weighs 37 criths. It boils at 35° C., and fuses at −31°. Its specific gravity is ·74, and the specific gravity of the vapour compared with air is $37 \times {\cdot}0693 = 2{\cdot}564$. When inhaled it produces intoxicating effects, causing sleepiness and insensibility, and it was used as an anæsthetic until superseded by chloroform.

The liquid is highly refractive. It is very inflammable, burning with a yellowish-white flame forming water and carbonic anhydride, and requires six times its volume of oxygen for complete combustion, thus: $C_4H_{10}O + 12O = 5OH_2 + 4CO_2$. When mixed with air or oxygen it forms a dangerous explosive mixture, and care should be taken not to have flame of any kind in the vicinity when the vapours are condensing. When unconfined it vapourizes so quickly as to produce intense cold. It is consequently used to produce artificial cold. A mixture of ether and solid carbonic anhydride produces a temperature of − 110° C., which is the greatest cold yet produced, excepting one of − 140° C. It can be mixed with alcohol in all proportions, and an equal bulk of water dissolves about one-eighth of its volume of ether. It is decomposed, when passed through heated porcelain tubes, into aldehyde and carbon, and at a lower temperature olefiant gas and acetylene are produced. When it is kept in a vessel in which there is air, acetic acid is formed by the absorption of oxygen. With H_2SO_4 it forms sulphovinic acid—with HNO_3 it forms oxalic and acetic acids and carbonic anhydride. With HCl, HBr, and HI it forms hydrochloric, hydrobromic, and hydriodic ethers. It is decomposed by sodium and potassium, hydrogen being given off.

It is decomposed by dry chlorine into dichlorinated ether, $(C_2H_3Cl_2)_2O$, and perchlorinated ether, $(C_2Cl_5)_2O$. It dissolves oils and fats, nitric oxide, ammonia, I, P, S, and auric, ferric, mercuric, and platinic chlorides. It also combines with acetic, butyric, caproic, œnanthylic, pelargonic, and capric acids, forming ethers named after these acids.

Haloid ethers are compounds of the alcohol radicals with the negative or chlorous elements, Cl, Br, I, F, or CN, which take the place of the hydroxyl.

From the monohydric alcohols are obtained the following series of haloid ethers, having the general formulæ—$C_nH_{2n+1}Cl$, $C_nH_{2n-1}Cl$, and $C_nH_{2n-7}Cl$. From the dihydric alcohols are obtained haloid ethers of the forms $C_nH_{2n}HOCl$ and $C_nH_{2n}Cl_2$.

From the trihydric alcohols are obtained haloid ethers of the forms $C_nH_{2n-1}HO_2Cl$, $C_nH_{2n-1}HOCl_2$, $C_nH_{2n-1}Cl_3$, and $C_nH_{2n-1}OCl$.

As the monohydric alcohols only contain one semimolecule of hydroxyl they form but one haloid ether. As the dihydric alcohols contain two semimolecules of hydroxyl the negative element can displace one or both semimolecules of hydroxyl, and thus form two classes of haloid ethers. As the trihydric alcohols contain three semimolecules of hydroxyl the negative element can displace one, two, or three semimolecules of hydroxyl, thus forming three classes of haloid ethers. A fourth class is formed by substituting, instead of the three semimolecules of hydroxyl, one of oxygen and one of the negative element.

Ethylic chloride, C_2H_5Cl, is prepared by saturating C_2H_5HO with HCl, and heating the mixture in a flask for two hours at 100° C., when EtCl forms the upper layer. It is passed through warm water and over calcic chloride, and into a tube kept cool by a freezing-mixture, when it is condensed to the liquid state. It is prepared by heating a mixture of two parts of EtHO, three of H_2SO_4, and four of NaCl in a retort connected with a receiver, surrounded by water at a temperature of about 20° C., in which any water or alcohol passing over is condensed, and EtCl passes on to another flask cooled by water at 0° C. It is also prepared by heating phosphorus trichloride and anhydrous ether in a sealed tube to a temperature of 193° C., when phosphorus anhydride and ethylic chloride are formed, thus: $3\,(C_2H_5)_2O + 2PCl_3 = 6C_2H_5Cl + P_2O_3$.

Chlorides of zinc, tin, &c., acting on ethylic alcohol produce this haloid ether. It is a colourless liquid having an agreeable odour, and is very volatile. Its molecular weight is 64·5, and a litre of its vapour weighs 32·25 criths. It has a specific gravity of ·87 and boils at 12° C. The flame produced by burning its vapour has a greenish tinge. Alcohol dissolves it freely and water slightly. When it and an alcoholic solution of potassic hydrate are heated in a sealed tube to 100° C., ethylic ether and potassic chloride are formed, thus: $2C_2H_5Cl + 2KHO = 2KCl + OH_2 + (C_2H_5)_2O$. When it is passed through a red-hot tube hydrochloric acid and olefiant gas are produced, thus: $C_2H_5Cl = HCl + C_2H_4$. And when its vapour is passed over heated caustic potash, olefiant gas, potassic chloride, and water are formed, thus: $C_2H_5Cl + KHO = C_2H_4 + KCl + OH_2$.

Ethyl iodide, C_2H_5I, is prepared by placing one part by weight of phosphorus in a retort with condensing apparatus, and a glass globe fitted into the tubulature with a tube and tap. And two parts by weight of alcohol are poured on five parts of iodine, and the solution poured into the globe. The phosphorus is melted by heating the retort in a water-bath, and the alcoholic solution of iodine is allowed to flow in small quantities into the retort. The first portion of the distillate is used to dissolve any iodine remaining undissolved in the vessel in which the mixture was made, and is transferred to the retort and the distillation continued. Or the phosphorus and alcohol are placed in the retort, and the iodine, dissolved by ethyl iodide, is allowed to flow into the retort slowly during the distillation. Or the alcohol is poured into the retort, and a little iodine added, and phosphorus introduced, very little at a time, until the solution becomes colourless. More iodine is added, and then a little phosphorus, until quantities in about the above proportions have been introduced. The violent action in the retort is moderated by putting the bulb in cold water. This mixture is distilled as before. The distillate is washed with water, digested in calcic chloride, and redistilled to obtain pure. It is a heavy colourless liquid, having a molecular weight of 156, and a litre of the vapour weighs 78 criths. Its specific gravity is 1·95. It boils at 72° C. When kept in a bottle not well stoppered it turns brown from the liberation of iodine. It also turns brown by the action of light. It is generally employed in the preparation of ethyl compounds. When it is put with water in a tube and the tube sealed and heated to about 150° C., it is decomposed into hydriodic acid and ether. Zinc decomposes ethyl iodide in a sealed tube, the radical ethyl being formed. When a mixture of ethyl and methyl iodides in equal quantities is treated with argentic oxide, ethyl-methyl ether is produced, thus: $C_2H_5I + CH_3I + OAg_2 = 2AgI + C_2H_5CH_3O$. When this iodide is heated with argentic oxide in a sealed tube, ether and argentic iodide are formed, thus: $2C_2H_5I + OAg_2 = (C_2H_5)_2O + 2AgI$. When it is boiled with argentic oxide and water, argentic iodide and alcohol are formed, thus: $2C_2H_5I + OH_2 + OAg_2 = 2C_2H_5HO + 2AgI$.

The ethereal salts correspond to the metallic salts of acids. The base must always be organic, but the acid may be either inorganic or organic. They are generally formed by heating together an alcohol and an acid, when water and an ethereal salt are formed. The reaction is exactly parallel with that occurring when an ordinary basic oxide and acid are brought together, thus:

$$KHO + NO_2HO = NO_2KO + OH_2 \text{ and}$$
$$C_2H_5HO + NO_2HO = NO_2C_2H_5O + OH_2.$$

However, they differ from the metallic salts in being soluble in alcohol and scarcely soluble in water, and in being generally uncrystallizable. Besides, they are generally volatile liquids having an aromatic odour. It is generally advisable in their preparation to act on a potassic salt of the acid by a sulpho-acid of the radical. The ethereal salts are decomposed by water and alkalies, just like the metallic salts, thus: $C_2H_5COHO + OH_2 = C_2H_5HO + HCOHO$, and $CH_3COEtO + KHO = EtHO + CH_3COKO$.

The monobasic acids form one ethereal salt with each monohydric alcohol, two with dihydric alcohols, and three with trihydric alcohols. The dibasic acids form two series of ethereal salts with monohydric alcohols, the normal and acid. The tribasic acids form three series of salts with monohydric alcohols, one normal and two acid.

Acetic ether, CH_3COEtO, is prepared by mixing three parts of strong H_2SO_4 with two parts of alcohol and standing aside for a day. Melt some sodic acetate, allow to cool, and put four parts of this in small pieces in a retort. On this pour the mixture, and set aside for a day, and distil, when the ether is given off, thus: $2C_2H_5HO + 2CH_3CONao + 2H_2SO_4 = 2OH_2 + 2HNaSO_4 + 2C_2H_5 C_2H_3O_2$. It is dried with calcic chloride and redistilled. It may be prepared by distilling two parts of EtHo, three parts of H_2SO_4 and eight of dry plumbic acetate, thus: $2C_2H_5HO + Pb2CH_3CO_2 + H_2SO_4 = 2C_2H_5C_2H_3O_2 + PbSO_4 + OH_2$. It is a colourless liquid, boiling at 74° C. It has a pleasant odour, and a burning taste. It dissolves resins and essential oils. It dissolves calcic chloride, forming a crystalline compound, which, on being heated, gives off the pure ether. Potassic hydrate decomposes it into alcohol and potassic acetate, thus: $CH_3COEtO + KHO = EtHO + CH_3COKO$.

Butylic ether, C_3H_7COEtO, may be prepared by shaking two parts of butyric acid, and two of ethylic alcohol, with one part of H_2SO_4, when the mixture on standing separates into two layers, the upper being butyric ether. Agitate the ether with water, and afterwards distil with calcic chloride. It may also be prepared by distilling together alcohol, sulphuric acid, and sodic butyrate, thus: $C_3H_7CONao + C_2H_5HO + H_2SO_4 = HNaSO_4 + OH_2 + C_3H_7COEtO$. Or by distilling calcic hydrate, alcohol, and sulphuric acid. Its molecular weight is 116, and a litre of its vapour weighs 58 criths. It is a liquid having a specific gravity of ·9, and boils at 119° C. It has the odour of pine-apples, and is extensively used in confectionery for flavouring creams, custards, and ices. It is also used in doctoring bad rum. When inhaled it produces headache and irritates the air-tubes of the lungs. It is sold as artificial pine-apple oil, and is used in the manufacture of compound perfumes.

METHYL CHLORIDE, CHLOROFORM, ETHYLENIC BROMIDE.

Methylic chloride, MeCl or CH_3Cl, is formed when marsh-gas, MeH, is mixed with chlorine in the daylight, thus: $MeH + Cl_2 = MeCl + HCl$. It is also formed by heating sulphuric acid, methylic alcohol, and common salt together, thus: $MeHO + H_2SO_4 = MeHSO_4 + OH_2$, and $MeHSO_4 + NaCl = MeCl + NaHSO_4$. Chlorine, acting on methylic chloride, forms CH_2Cl_2, $CHCl_3$, and CCl_4, having boiling-points of 41°, 62°, and 77° respectively. Methylic chloride boils at $-21°$. Its molecular weight is 50·5, and one litre of the vapour weighs 25·25 criths. Chloroform, $CHCl_3$, is prepared by making a thin paste of four parts of chloride of lime (bleaching-powder) and water, to which add one part of ethylic or two of methylic alcohol. Place this mixture in a retort capable of holding twice the quantity, and heat to 82° C., when chloroform, with water and a little alcohol, distil over. The water and alcohol forming the upper layer are poured off cautiously, and the remaining chloroform is agitated with fused potassic carbonate, which abstracts traces of water. The result, when redistilled, is pure chloroform ready for use. $2MeHO + 4CaOCl_2 = 2CHCl_3 + 3OH_2 + (CaO)_2O(CaCl)_2$. $EtHO + 4CaOCl_2 = 2CHCl_3 + 2OH_2 + (CaO)_2O(CaCl)_2$. It can be prepared by the action of potassic hydrate on chloral, thus: $C_2Cl_3HO + KHO = CHCl_3 + HCOKO$. It is produced by the action of chlorine on methylic chloride, thus: $CH_3Cl + 2Cl_2 = 2HCl + CHCl_3$. It is produced by the decomposition of potassic trichloracetate by potassic hydrate, thus: $CCl_3COKO + KHO = COKO_2 + CHCl_3$. It can also be produced by mixing one measure of methylic hydride and one of carbonic anhydride, with four of chlorine, in the daylight, thus: $2MeH + 7Cl_2 = 7HCl + CCl_4 + CHCl_3$. The CO_2 is merely added to prevent explosion. Chloroform is a colourless, limpid, mobile, volatile liquid, having a pleasant, characteristic odour, and a pleasant, sweetish taste. Its molecular weight is 119·5, and one litre of the vapour weighs 59·75 criths. It boils at 62° C., and the liquid weighs nearly half as heavy again as water. It is scarcely soluble in water, but ether and alcohol dissolve it in every proportion. It dissolves resins, fats, alkaloids, phosphorus, sulphur, caoutchouc, bromine, iodine, &c. When thrown on a red-hot fire it burns with a greenish, smoky flame; but does not burn when an ordinary light is brought into contact. When agitated with H_2SO_4 it should swim on the surface on settling, and both layers should remain colourless. When a little is evaporated on the hand, no alcoholic or other odour should be observed, if pure. Potassium does not affect it, but alcoholic potash transforms it into the potassic formate and chloride, thus: $CCl_3H + 4KHO = HCOKO + 3KCl + 2OH_2$. Strong light decomposes it. Chlorine, in the sunlight, displaces the remaining hydrogen of chloroform, thus: $CHCl_3+Cl_2=CCl_4+HCl$. Ammonic hydrate, and powdered zinc acting on it, replace hydrogen, thus: $CHCl_3+H_2=CH_2Cl_2+HCl$. Chloroform is generally considered to be the analogue of methylic chloride, from which it is regarded as being formed by the substitution of chlorine for hydrogen; thus we have CH_2Cl_2, $CHCl_3$ (chloroform), and CCl_4. By the substitution of bromine or iodine for chlorine in chloroform, we have bromoform or iodoform. It is extensively employed to produce insensibility to pain during surgical operations. In America ethylic ether is preferred. Dr. Richardson recommends the bichloride, CH_2Cl_2, as a substitute for chloroform. Nitrous oxide and carbonic anhydride are other anæsthetics. Chloroform can be administered by placing it before the mouth on a sponge or other porous substance and inhaling it, when an insensibility to pain is produced, but it should only be taken under medical advice, for on certain constitutions it produces fatal effects. It was first used by Simpson, of Edinburgh, about 1848, and has since that time increased in estimation. It is one of the greatest boons that chemical research has rendered subservient to suffering humanity.

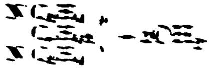
Ethylenic bromide, $C_2H_4Br_2$, is prepared by agitating bromine water with ethylene. Its molecular weight is 188, and one litre of the vapour weighs 94 criths. The liquid has a specific gravity of 2·16, boils at 130° C., and fuses at – 18° C. When heated with alcoholic potassic acetate, it produces monacetic gylcol and acetic acid, thus: $Et''Br_2 + 2MeCOKo + OH_2 = 2KBr + MeCOHo + \left\{\begin{matrix}CH_2(CMeO)O\\ CH_2HO\end{matrix}\right.$. When boiled with alcoholic potash it forms vinylic bromide, thus: $Et''Br+KHo=OH_2+KBr+C_2H_3Br$.

THE ALDEHYDES.

The aldehydes are compounds formed by the oxidation of the alcohols. Thus methyl alcohol, $HCH_2Ho+O=$

$OH_2 + HCOH$ (formic aldehyde). The aldehydes on further oxidation are converted into acids, thus: $HCOH + O = HCOHo$ (formic acid). In the same way ethylic alcohol is converted by oxidation into acetic aldehyde, and by further oxidation into acetic acid, thus: $CH_3CH_2Ho + O = OH_2 + CH_3COH$ (acetic aldehyde) and $CH_3COH + O = CH_3COHo$ (acetic acid). The alcohols, like other organic compounds, when burned with a sufficient supply of oxygen or air, form water and carbonic anhydride; but if the combustion is effected at a low temperature with an insufficient supply of air, aldehyde and other compounds are formed. The alcohols may be oxidized by a mixture of manganic oxide and sulphuric acid. From these reactions we see that the aldehydes are compounds intermediate between the alcohols and the corresponding acids. Methylic alcohol HCH_2Ho, ethylic CH_3CH_2Ho, propylic $C_2H_5CH_2Ho$, butylic $C_3H_7CH_2Ho$, &c., all contain the group CH_2HO, and oxygen unites with H_2 of the group, forming water (OH_2) and leaving COH, which is the group common to all the aldehydes, thus: $HCOH$, CH_3COH, C_2H_5COH, C_3H_7COH, &c., are respectively formic, acetic, propionic, butyric, &c., aldehydes, and the acids are characterized by the group $COHo$, which is formed by oxygen uniting with the aldehyde group COH, becoming $COHo$. Formic, acetic, propionic, butyric, &c., acids are respectively symbolically represented by $HCOHO$, CH_3COHo, C_2H_5COHo, C_3H_7COHo, &c. The group COH of the aldehydes is converted into the corresponding alcohol by the action of nascent hydrogen, forming the group CH_2HO, the alcohol radical C_nH_{2n+1} remaining unchanged. There are aldehydes formed from the monohydric alcohols, $C_nH_{2n+1}Ho$, $C_nH_{2n-1}Ho$, and $C_nH_{2n-7}Ho$. There is also an aldehyde glyoxal $(COH)_2$ formed by the abstraction of 4 atoms of hydrogen from glycol $(CH_2HO)_2$, or by the oxidation of alcohol by nitric acid, thus: $CH_3CH_2Ho + O_3 = 2OH_2 + (COH)_2$. The following are the aldehydes derived from the $C_nH_{2n+1}Ho$ series of alcohols—viz. formic, acetic, propionic, butyric, valeric, œnanthic, caprylic, capric, euodic, lauric, and palmitic, represented symbolically by $HCOH$, CH_3COH, C_2H_5COH, C_3H_7COH, C_4H_9COH, $C_6H_{13}COH$, $C_7H_{15}COH$, $C_9H_{19}COH$, $C_{10}H_{21}COH$, $C_{11}H_{23}COH$, $C_{15}H_{31}COH$ respectively. The aldehydes can be formed by distilling the potassic salt of the acid series, C_nH_{2n+1}, with potassic formate, thus: $CH_3COKo + HCOKo = COKo_2 + CH_3COH$. The aldehyde CH_3COH is converted by nascent hydrogen into the alcohol, thus: $CH_3COH + H_2 = CH_3CH_2Ho$. Sulphuric acid converts the alcohols into sulphovinic acid, thus: $CH_3CH_2Ho + H_2SO_4 = HC_2H_5SO_4 + OH_2$, and potassic cyanide converts the sulphovinic acid into ethylic nitrile, thus: $HC_2H_5SO_4 + KCN = HKSO_4 + C_2H_5CN$. Potassic hydrate converts the nitrile into the propionate, thus: $C_2H_5CN + KHo + OH_2 = C_2H_5COKo + NH_3$. Thus, by starting with potassic acetate, CH_3COKo, we have by this series of reactions ascended to potassic propionate, C_2H_5COKo, and by starting again with the latter we can obtain C_3H_7COKo, the next higher, and so on, ascending the series of fatty acids.

The aldehydes combine with oxygen, forming acids, thus: $C_nH_{2n+1}COH + O = C_nH_{2n+1}COHo$. They combine with hydrogen, forming the alcohols, thus: $C_nH_{2n+1}COH + H_2 = C_nH_{2n+1}CH_2Ho$. They combine with ammonia, forming crystalline compounds, thus: $C_nH_{2n+1}COH + NH_3 = C_nH_{2n+1}CONH_4$. They also produce crystalline compounds with the alkaline hydric sulphites, thus: $C_nH_{2n+1}COH + HKSO_3 = HKSO_3C_nH_{2n+1}COH$. When heated with an ammonia solution of argentic oxide, metallic silver is deposited, and they are converted into acids, thus: $C_nH_{2n+1}COH + OAg_2 = C_nH_{2n+1}COHo + Ag_2$. When heated with potassic hydrate hydrogen is given off and a potassic salt is formed, thus: $C_nH_{2n+1}COH + KHo = H_2 + C_nH_{2n+1}COKo$. Sodium and potassium decompose the aldehydes, thus: $2C_4H_9COH + K_2 = 2C_4H_9COK + H_2$. Aniline acting on the aldehydes forms diamines, thus: $2CH_3COH + 2C_6H_5NH_2 =$



$$\left.\begin{array}{l} N(C_2H_4) \\ \;(C_2H_4) \\ N(C_2H_4) \end{array}\right\} + [illegible]$$

Hydrocyanic acid converts aldehyde into amido-acids, thus: $CH_3COH + HCN + OH_2 = N(C_2H_4COHo)H_2$, which is known as lactamic acid, an amido-acid.

Acetic aldehyde can be best prepared by acting on alcohol C_2H_5Ho by potassic dichromate and sulphuric acid, and allowing the gas given off to pass into ether, into which ammonia is passed. The ammonia forms with the aldehyde the compound CH_3COHNH_3, which gives the aldehyde when distilled with dilute sulphuric acid. Or by oxidizing C_2H_5Ho in various other ways. When the vapour of alcohol and air are passed through a porcelain tube heated to dull redness aldehyde is formed. It is prepared by placing four parts of C_2H_5Ho, four of OH_2, six of H_2SO_4, and six of MnO_2 in a retort, and distilling, when aldehyde passes off and is condensed in a receiver cooled by ice. By calcic chloride it is freed from water and alcohol. It is then mixed with ether and separated as described above. It is also formed by the oxidation of albumen, caseine, fibrine, by the dry distillation of lactic acid or a lactate, and by the action of chlorine on dilute C_2H_5Ho. Again, it is formed when the dichloride of diethylene diamine, $N_2(C_2H_4)_2H_2$, is acted on by argentic nitrate and a small quantity of sulphuric acid, thus: $N_2(C_2H_4)_2H_2Cl_2 + 2NO_2AgO = 2AgCl + 2OH_2 + 2N_2 + 2CH_3COH$. Acetic aldehyde has a molecular weight of 44, and 1 litre of the vapour weighs 22 criths. It boils at 22° C. It is an inflammable, volatile, colourless liquid having a specific gravity of ·8. It has a suffocating odour. It mixes in all proportions with water, alcohol, and ether. It gradually absorbs oxygen from the air, forming acetic acid. It unites with nascent hydrogen, forming alcohol. It reduces silver salts to the metallic state. Potassium acting on it forms CH_3COK, hydrogen being evolved. Phosphoric chloride acting on it produces ethylidenic dichloride, thus: $CH_3COH + PCl_5 = POCl_3 + CH_3CHCl_2$.

Nitrous anhydride converts lactamic acid or alanin into lactic acid, thus: $N(C_2H_4COHo)H_2 + N_2O_3 = 2C_2H_4HOCOHo + 2OH_2 + 2N_2$. And hydrocyanic acid changes it into lactamic acid, thus: $CH_3COH + HCN + OH_2 = N(C_2H_4)H_2COHo$. Chlorine acting on it produces chloral, thus: $CH_3COH + 3Cl_2 = CCl_3COH + 3HCl$. When treated with potassic hydrate a brown resinous mass is produced.

When aldehyde is kept in a sealed tube it changes into elaldehyde, a liquid, and metaldehyde, a solid crystalline body, both of which are isomeric with it. Paraldehyde is another isomeric form, produced by diluting it with an equal volume of water, having a trace of nitric or sulphuric acid, and exposing to the temperature of 0° C., when metaldehyde crystallizes, and the paraldehyde remains in the liquid state. When it is digested with a saturated solution of sodic formiate in a sealed tube at 100° C. for two or three hours it loses water, thus: $2CH_3COH = C_4H_6O + OH_2$. When it is treated with acetic anhydride in a sealed tube to 183° C. they unite, forming a colourless liquid, thus: $(C_2H_3O)_2O + CH_3COH = CH_3COH(C_2H_3)_2O$, or $C_6H_{10}O_4$.

Benzoic aldehyde, C_6H_5COH, is obtained from the cake which is left after the fixed oil of almonds has been pressed out of the bitter almonds. This cake contains amygdalin and synaptase or emulsin. It is crushed and made into a paste with water, when the emulsin acts as a ferment on the amygdalin. The paste is put in a retort, and after a day heat is applied gradually and it is distilled, when the essential oil passes into the receiver, accompanied by hydrocyanic acid and water. It can be purified by submitting it to the action of ferrous chloride and calcic hydrate and distilling, when the pure oil passes into the receiver freed from prussic or hydrocyanic acid, which is very poisonous.

Amygdalin, $C_{20}H_{27}NO_{11} + 2OH_2 = HCN + 2C_6H_{12}O_6 + C_6H_5COH$. It is produced by the oxidation of amygdalin by nitric acid, and by the oxidation of albumen, caseine, fibrine, and gelatine by sulphuric acid and binoxide of manganese.

It is also produced by heating benzylic chloride and plumbic nitrate with water, thus: $2C_7H_7Cl + Pb(NO_3)_2 = OH_2 + N_2O_3 + PbCl_2 + 2C_6H_5COH$. It is a colourless liquid, having a bitter taste and an agreeable odour. It burns with a smoky flame, and is inflammable. Heated to 180° C. it boils and distils over unaltered. It is dissolved by ether and alcohol in all proportions, and to the extent of three per cent. by OH_2. When exposed to the air it oxidizes into benzoic acid. Nascent hydrogen converts it into benzyl alcohol, thus: $C_6H_5COH + H_2 = C_6H_5CH_2Ho$. When heated with solid potassic hydrate, potassic benzoate is formed, thus: $C_6H_5COH + KHo = C_6H_5COKo + H_2$. When treated with phosphoric chloride chlorobenzol is formed, thus: $C_6H_5COH + PCl_5 = POCl_3 + C_6H_5CHCl_2$. It is converted into nitro-benzoic acid by concentrated nitric acid, thus: $C_6H_5COH + HNO_3 = OH_2 + C_7H_5NO_3$. It is sold under the name of hydride of benzoyle. In medicine it is used instead of prussic acid. It is used for scenting soaps and for flavouring confectionery.

ORGANIC ACIDS—MONOBASIC, DIBASIC, TRIBASIC, AND POLYBASIC—PREPARATION AND PROPERTIES OF ACETIC, LACTIC, AND BENZOIC ACIDS.

The organic acids constitute a very important class of compounds. They are monobasic, dibasic, tribasic, or polybasic, according as they contain one, two, three, or more semimolecules of oxatyl $(COHo)_2$. Formic acid, HCOHo, is monobasic, forming only HCOKo, since it contains only one semimolecule, COHo, of oxatyl.

Oxalic acid is dibasic, because it contains two semimolecules of oxatyl, and forms $COHo$, $COKo$, and $(COKo)_2$.

Citric acid contains three semimolecules of $(COHo)_2$, and is written

$$\left\{\begin{array}{l} CH_2COHo \\ CHCOHo \\ CHHOCOHo \end{array}\right.$$

in which one, two, or three of the atoms of hydrogen in the three semimolecules of oxatyl can be replaced by one, two, or three atoms of a monad metal, such as potassium; thus we have the following salts, viz.,

$$\left\{\begin{array}{l} CH_2COKo \\ CHCOHo \\ CHHOCOHo \end{array}\right. \quad \left\{\begin{array}{l} CH_2COKo \\ CHCOKo \\ CHHOCOHo \end{array}\right. \quad \text{and} \quad \left\{\begin{array}{l} CH_2COKo \\ CHCOKo \\ CHHOCOKo \end{array}\right.$$

Pyromellitic acid, $C_6H_2(COHo)_4$, contains four semimolecules of oxatyl, and is therefore tetrabasic—that is, the H in the four groups of $COHo$ can be displaced by one, two, three, or four atoms of a monad metallic element.

Mellitic acid, $C_6(COHo)_6$, contains six semimolecules of oxatyl, and is hexabasic. The intermediate pentabasic acid, $C_6H(COHo)_5$, is unknown.

The monobasic acids, having the general formula $C_nH_{2n+1}COHo$, are derived from the methyl series of alcohols. The oleic or acrylic series, having the general formula $C(C_nH_{2n})''(C_mH_{2m+1})COHo$, is derived from the vinyl series of alcohols. The lactic series, having the general formula $C(C_nH_{2n+1})(C_mH_{2m+1})HOCOHo$, is derived from the glycol series of alcohols. The glyoxylic series, having the general formula $C(C_nH_{2n+1})Ho_2 COHo$, is derived from the glycerine series of alcohols. The aromatic or benzoic series, having the general formula $C_nH_{2n-7}COHo$, is derived from the phenyl series of alcohols. And the pyruvic series, having the general formula $CO(C_nH_{2n+1})COHo$, are the semiketones of oxalic acid. The fatty or acetic series contains formic, acetic, propionic, butyric, valeric, caproic, œnanthylic, caprylic, pelargonic, capric, lauric, myristic, palmitic, margaric, stearic, arachic, behenic, hyaenic, cerotic, and melissic acids, having the formulæ H, CH_3, C_2H_5, C_3H_7, C_4H_9, C_5H_{11}, C_6H_{13}, C_7H_{15}, C_8H_{17}, C_9H_{19}, $C_{11}H_{23}$, $C_{13}H_{27}$, $C_{15}H_{31}$. $C_{16}H_{33}$, $C_{17}H_{35}$, $C_{19}H_{39}$, $C_{21}H_{43}$, $C_{24}H_{49}$, $C_{26}H_{53}$, and $C_{29}H_{59}$ respectively, to each of which the group COHo is attached, rendering them all monobasic acids.

The oleic or acrylic series contains acrylic, methacrylic, crotonic, methylcrotonic, ethylcrotonic, olefinecrotonic, angelic, pyroterebic, damaluric, damolic, moringic, physetoleic, oleic or elaidic, doeglic, and erucic, having the formulæ C_2H_3, $CMe''Me$, $CEt''H$, $CEt''Me$, $CEt''Et$, $CMe''HCH_2$, $CPr''H$, $CBu''H$, C_6H_{11}, $C_{12}H_{23}$, $C_{14}H_{27}$, $C_{15}H_{29}$, $C_{17}H_{33}$, $C_{18}H_{35}$, and $C_{21}H_{41}$ respectively, to each of which the group COHo is attached.

The lactic series contains glycolic, methyl glycolic, lactic, ethyl-lactic, aceto-lactic, paralactic, oxybutyric, dimethoxalic, ethomethoxalic, diethoxalic, valerolactic, leucic, and paraleucic acids, having the formulæ CH_2Ho, CH_2Meo, CHMeHo, CHMeEto, $CHMeC_2H_3O_2$, $(CH_2)_2Ho$, CHEtHo, $CHMe_2o$, CHMeEto, $CHEt_2o$, $(CH_2)_2Eto$, $(CH_2)_3Eto$, and $(C_4H_8)''CH_2Ho$ respectively, to each of which the group COHo is attached.

The glyoxylic series contains glyoxylic and glyceric acids, having the formulæ $CHHo_2$ and CH_2Ho CHHo respectively, to both of which the group COHo is attached.

The aromatic or benzoic series contains benzenic, benzoic, xylic, alpha-xylic, toluylic, alpha-toluylic, creosotic, cuminic, and alpha-cymic acids, having the formulæ C_5H_3, C_6H_5, $C_6H_3Me_2$, $CH_2(C_6MeH_4)$, C_6MeH_4, $C(C_6H_5)H_2$, $C(C_6H_5)H_2O$, $CEt(C_6H_5)H$, and $C_6Et_2H_3$ respectively, to all of which the group COHo is attached.

The pyruvic series contains pyruvic, convolvulinoleic, jalapinoleic, and ricinoleic acids, having the formulæ COMe, $CO(C_{11}H_{23})$, $CO(C_{14}H_{29})$, and $CO(C_{16}H_{33})$ respectively, to all of which the group COHo is attached.

The dibasic acids may be conveniently divided into the fumaric, tartaric, malic, and succinic, having the general formulæ $(C_nH_{2n-1})_2(COHo)_2$, $(C_nH_{2n-1}Ho)_2(COHo)_2$, $C_nH_{2n-1}HOC_nH_{2n}(COHo)_2$, and $C_nH_{2n}C_mH_{2m}(COHo)_2$.

The fumaric series contains fumaric and itaconic acids, having the formulæ $(CH)_2(COHo)_2$ and $C_3H_4(COHo)_2$ respectively.

The tartaric series contains tartaric and glycomalic acids, having the formulæ $(CHHo)_2(COHo)_2$ and $C(CHHo)_2(COHo)_2H_2$ respectively.

The malic series contains malic and tartronic acids, having the formulæ $CMeHO(COHo)_2$ and $CHHo(COHo)_2$ respectively.

The succinic series contains malonic, succinic, pyrotartaric, adipic, pimelic, suberic, anchoic, sebacic, and roccellic acids, having the formulæ $CH_2(COHo)_2$, $(CH_2)_2(COHo)_2$, $C_3H_6(COHo)_2$, $C_4H_8(COHo)_2$, $(CH_2)_5(COHo)_2$, $(CH_2)_6(COHo)_2$, $(CH_2)_7(COHo)_2$, $(CH_2)_8(COHo)_2$, and $(CH_2)_{15}(COHo)_2$.

Tetrahydrophthalic, hexahydrophthalic, tartrophthalic, and alizaric acids are dibasic, and have the formulæ $(C_3H_4)_2(COHo)_2$, $(C_3H_5)_2(COHo)_2$, $(C_3H_4HO)_2(COHo)_2$, and $C_6(CH)_6(COHo)_2$ respectively.

The tribasic acids contain citric, tricarballylic, and aconitic, having the formulæ $C_3H_5O(COHo)_3$, $C_3H_5(COHo)_3$, and $(CH)_3(COHo)_3$ respectively.

Pyromellitic acid, $C_6H_2(COHo)_4$, is tetrabasic. A pentabasic acid is unknown. Mellitic acid, $C_6(COHo)_6$, is hexabasic.

Acetic acid, CH_3COHo, is prepared by the destructive distillation of wood at a red heat in iron retorts. During the distillation tarry matter, wood naphtha, acetone, methyl acetate, &c., are given off. These products are condensed in receivers, and the liquid is decanted from the tarry matter. When this liquid is distilled, wood naphtha comes over, then the acid with some of the tar. Sodic carbonate or calcic hydrate is added to the distillate, when tar rising to the surface is skimmed off. The crude acetate is evaporated to dryness. The dry residue is gently roasted to get rid of impurities, and is decomposed by H_2SO_4 if it is a sodic acetate, and by HCl if a calcic acetate. It is also manufactured from saw-dust, shavings, chips, &c. The saw-dust is supplied through a hopper on to an endless chain, which is worked over rollers by a steam-engine, the saw-dust being carried along the lower part of the retort in contact with a furnace. The volatile matter passes into a condenser, and the carbonized saw-dust falls into a cistern of water. By another plan an archimedian screw, worked by machinery, passes the saw-dust, &c., from one end of the retort to the other, during which the volatile matters pass through a pipe from the tube to the condenser, while the carbonized wood falls out at the other end. One hundred parts of the dry wood of birch, beech, oak, ash, white poplar, and Scotch fir give 4·4, 4·3, 3·9, 3·7, 3·2, and 2·1 parts of pure acid respectively. It may be obtained in a state of purity by distilling potassic diacetate, thus: $(CH_3)_2COKoCOHo = CH_3COKo + CH_3COHo$. It is prepared by the oxidation of alcohol by allowing the alcohol to trickle over shavings soaked with vinegar. It is also obtained by the reaction of sulphuric acid on sodic acetate. From the symbolic formula the molecular weight is 60, and 1 litre of the vapour will therefore weigh 30 criths. It is a colourless liquid, having a specific gravity of 1·06, boiling at 118° C., and freezing at 17° C. It is found in animal fluids and the juices of vegetables. The strong acid has a pungent odour and an aromatic taste. On combustion it produces water and carbonic anhydride. Water dissolves it in all proportions, and it is soluble in alcohol. When heated it volatilizes, leaving no residue. It yields acetylic chloride when acted on by phosphorous chloride, thus: $3CH_3COHo + PCl_3 = POHHo_2 + 3CH_3COCl$. When acted on by chlorine in the daylight three chlorinated compounds are produced by the chlorine taking the place of one, two, or three atoms of hydrogen in the radical CH_3; thus we have $CH_2ClCOHo$, $CHCl_2COHo$, and CCl_3COHo, and HCl is produced in the reaction. Aluminic, ferric, plumbic, potassic, and sodic acetates are its most important salts.

All acetates are soluble in water. On heating a solid acetate with strong sulphuric acid and alcohol, acetic ether is formed, thus: $CH_3CONao + H_2SO_4 + EtHo = OH_2 + HNaSO_4 + CH_3COEto$. Acetates, when ignited, yield acetones, thus: $2CH_3CONao = CH_3COCH_3 + CONao_2$. When dry sodic acetate is heated with soda-lime, marsh-gas is formed, thus: $3CH_3CONao + CaHo_2 NaHo = 3CH_4 + COCao'' + 2CONao_2$. Ammonic acetate in presence of ammonia dissolves calcic and plumbic sulphate. Ferric chloride produces in a solution of an acetate a deep red-coloured solution, ferric acetate being formed. When an acetate is mixed with dilute H_2SO_4, and heated, acetic acid is set free, and a sulphate of the base is formed. Argentic nitrate produces in neutral solutions a white precipitate of argentic acetate, which is soluble in ammonic hydrate. Calcic chloride gives no precipitate with acetates.

Lactic acid ($CMeHHoCOHo$) is prepared by dissolving about 5 grm. of tartaric acid and a kilogramme of cane-sugar in 6 litres of boiling water and allowing to stand for a few days. Afterwards add one litre of sour milk, containing 30 grm. of bad cheese and 400 grm. of oxide of zinc, and put away for about ten days at a temperature of about 40° C. The zinc unites with the lactic acid, forming zinc lactate. The mixture is heated till it boils, and is filtered, and the filtrate evaporated, when the zinc lactate crystallizes in prisms. After re-crystallization it is dissolved in water, and SH_2 is passed through the solution, when the acid is set free and zinc sulphide is formed. The acid solution is evaporated on a water-bath, the residue is dissolved in some water, and agitated with ether, which takes up the acid. The solution of the acid in ether is evaporated, when the lactic acid remains as a colourless thick liquid. Chalk may be used instead of zinc oxide, when beautiful tufts of acicular prisms of calcic lactate are formed. These crystals are re-crystallized, and treated with one-third of their weight of H_2SO_4, and heated with alcohol, which dissolves the lactic acid, leaving calcic sulphate. Pure lactic acid remains on evaporating the alcoholic solution. It is formed by the oxidation of propylic glycol, thus: $CH_2MeoCH_2Ho + O_2 = OH_2 + CH_2MeoCOHo$.

Potassic hydrate converts chloropropionic acid into a lactate, thus: $CMeHClCOHo + 2KHo = OH_2 + KCl + CH_2MeoCOHo$. It is also produced from ethylidenic cyanhydrate, thus: $CH_3CH_2Cyo + KHo + OH_2 = NH_3 + CH_2MeoCOKo$. It is produced by the action of nitrous acid on alanin, thus: $CHMe(NH_2)COHo + HNO_2 = N_2 + OH_2 + CH_2MeoCOHo$. It is formed in sour milk, in malt vinegar, in plants, and in animals. Nascent hydrogen acting on pyruvic acid forms this acid, thus: $COMeCOHo + H_2 = CH_2MeoCOHo$. It is a colourless, transparent, syrupy, uncrystallizable liquid having a specific gravity of 1·22. Water, alcohol, and ether dissolve it in all proportions. It has an acid taste, and it is odourless. Cane-sugar, milk-sugar, dextrine gum, and starch pass readily into lactic acid under the influence of decomposing animal matter. It can be converted into propionic acid by saturating it with gaseous HI in the cold, then sealing in a tube and heating to 140° C., thus: $CMeHHoCOHo + 2HI = CMeH_2COHo + OH_2 + I_2$. When it is heated to about 260° C. it is decomposed, aldehyde, carbonic oxide, and water being formed. Nitric acid converts it into oxalic acid. It coagulates albumen. When the lactates are heated with H_2SO_4 they deposit a solid brown substance, and give off carbonic oxide. To detect it in a solution evaporate to the consistency of a syrup in a water bath, add ethylic alcohol, and a little of a solution of oxalic acid. Add baryta water, which precipitates baric oxalate, while the baric lactate remains in solution. Filter and add a solution of calcic sulphate, which precipitates baric sulphate, filter and evaporate, when crystals of calcic lactate are formed in tufts which can be verified by the microscope.

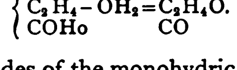
Benzoic acid, C_6H_5COHo, is prepared by sublimation from gum benzoin, of which about one-seventh consists of this acid. The gum benzoin is placed in a shallow iron pan covered with a sheet of filtering paper, over which is placed a cone of writing paper as a receiver. When the iron pan is heated the benzoic acid volatilizes, and condenses on the paper receiver in needle crystals. It may be prepared by boiling the gum benzoin in powder with calcic hydrate for several hours, filtering the insoluble lime and resin from the calcic benzoate, and, after concentrating the solution, add hydrochloric acid to precipitate the acid, which is obtained pure by sublimation. It is prepared by the oxidation of benzoic aldehyde or oil of bitter almonds, thus: $C_6H_5COH + O = C_6H_5COHo$. It is produced by decomposing phenyl cyanide by potassic hydrate, thus: $C_6H_5CN + KHo + OH_2 = C_6H_5COKo + NH_3$. It is prepared by converting naphthalin into phthalic acid by prolonged boiling with nitric acid, when phthalic acid is deposited in lamellar crystals on evaporation. Convert into calcic phthalate and heat for several hours to a temperature of about 340° C. with calcic hydrate without free access of air, when calcic benzoate is formed, thus: $2CaC_8H_4O_4 + CaHo_2 = 2COCao'' + Ca2C_7H_5O_2$. Dissolve and precipitate with HCl or H_2SO_4. It is produced by the joint action of carbonic anhydride and sodium on phenyl bromide, thus: $C_6H_5Br + CO_2 + 2Na = C_6H_5CONao + NaBr$. It is produced by oxidizing gluten or caseine, and by boiling hippuric acid with hydrochloric acid, when it assimilates the elements of water, and forms butyric acid, thus: $C_9H_9NO_3 + OH_2 = C_6H_5COHo + CH_2NH_2COHo$. It is produced by treating styrol, C_8H_8, with potassic permanganate solution, when this acid is formed, thus: $C_8H_8 + O_5 = OH_2 + CO_2 + C_6H_5COHo$. It is produced by acting on cinnamic acid with fused potassic hydrate, thus: $C_8H_7COHo + 2KHo = C_6H_5COKo + CH_3COKo + H_2$.

Benzoic acid is monobasic, and occurs in light feathery snow-white glittering crystals. It has a very fragrant, pleasant, aromatic odour, due to the presence of traces of the essential oil. It produces a peculiar hot sensation when some of the crystals are placed on the tongue. Water dissolves it slightly, and ether and alcohol freely. Its molecular weight is 122, and one litre of the vapour weighs 61 criths. It melts at 121° C., and boils at 240° C. Its vapour burns with a smoky flame. All benzoates, except those of tetral metals, are soluble in water. It sublimes when heated in a tube, forming needle-shaped crystals. Ferric chloride in a solution of a benzoate gives a red precipitate of ferric benzoate. Calcic chloride gives no precipitate in solutions, being soluble. Plumbic acetate gives a white precipitate of plumbic benzoate in solutions of sodic or potassic benzoate. When ammonic benzoate is treated with HCl it is decomposed, benzoic acid being precipitated in crystals.

THE ANHYDRIDES.

The anhydrides are substances derived from acids by the abstraction of sufficient oxygen and hydrogen to form water—two molecules of a monobasic acid being required to form the corresponding anhydride, thus: 2EtCOHo, propionic acid, = $(CEtO)_2O$, the anhydride, plus water, OH_2.

The anhydrides of dibasic and tribasic acids contain the elements of these acids minus a molecule of water, thus succinic acid:



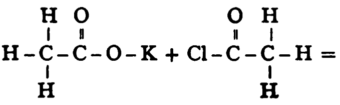
$$\left\{\begin{array}{l}COHo\\C_2H_4\\COHo\end{array}\right. - OH_2 = \begin{array}{l}CO\\C_2H_4O.\\CO\end{array}$$

There are anhydrides of the monohydric monobasic acids $(C_nH_{2n+1})_2(CO)_2O$ and $(C_nH_{2n-7})_2(CO)_2O$, anhydrides of the dihydric monobasic acids $(C_nH_{2n+1})_2(CO)_2$, and anhydrides of the dihydric dibasic acids $C_nH_{2n}(CO)_2O$. The anhydrides of the organic acids are similar in appearance, being oily bodies heavier than water, while the anhydrides of the inorganic acids are dissimilar, assuming various forms, solid and gaseous. The anhydrides of the organic acids unite with water to form the corresponding acids.

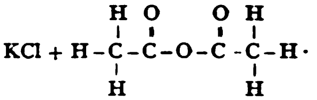
The anhydrides of the monohydric monobasic acids of the acetic and benzoic series are acetic $(CO)_2Me_2O$, propionic $(CO)_2Et_2O$, butyric $(CO)_2Pr_2O$, valeric $(CO)_2Bu_2O$, caproic $(CO)_2Ay_2O$, œnanthylic $(CO)_2Cp_2O$, benzoic $(CO)_2Ph_2O$, acetobenzoic $(CO)_2MePhO$, caprylic $(CO)_2Cy_2O$, pelargonic $(CO)_2Pe_2O$, and palenitic $(CO)_2Pa_2O$. These anhydrides are produced by the action of the chloracids on the potassic salts of the acids. Phosphoric chloride, PCl_5, acting on acetic acid, forms the oxychloride, thus: $CH_3COHo + PCl_5 = CH_3COCl + POCl_3 + HCl$. Acetic anhydride is formed by the action of CH_3COCl on CH_3COKo, producing

$$\left\{\begin{matrix}COMe\\COMe\end{matrix}\right.O, \text{ or } (CO)_2(CH_3)_2O.$$

It may also be obtained by the action of phosphoric oxychloride on potassic acetate, thus: $POCl_3 + 6CH_3COKo = 3KCl + K_3PO_4 + 3(CH_3)_2(CO)_2O$. In this reaction the oxychloride of acetic acid is formed, when it immediately reacts on the excess of the potassic acetate, thus: $POCl_3 + 3CH_3COKo = 3CH_3COCl + K_3PO_4$, and $3CH_3COCl + 3CH_3COKo = 3(CH_3)_2(CO)_2O + 3KCl$. The anhydride in the above reactions is formed by a substitution of the group CH_3CO, instead of K in the group CH_3COKo; thus, representing the action graphically, we have:



$$H-\underset{H}{\overset{H}{C}}-\overset{O}{\overset{\|}{C}}-O-K+Cl-\overset{O}{\overset{\|}{C}}-\underset{H}{\overset{H}{C}}-H=$$



$$KCl + H-\underset{H}{\overset{H}{C}}-\overset{O}{C}-O-\overset{O}{C}-\underset{H}{\overset{H}{C}}-H\cdot$$

the K and the Cl unite and form KCl, and the vacant bond of O is satisfied by that of C, as shown. Acetic anhydride is a colourless liquid having a high refractive power and the odour of acetic acid. It dissolves slowly in water, giving off heat, and forms acetic acid. When exposed to the air it absorbs moisture, thus:

$$\left\{\begin{array}{c} C(CH_3)O \\ O \\ C(CH_3)O \end{array}\right. + OH_2 = 2CH_3COHo.$$

The anhydrides of the dihydric monobasic acids are formed by heating the acids: thus $C_2H_4HOCOHo$ gives off OH_2 and becomes $C_2H_4CO_2$, the lactide, after being heated. Water dissolves this lactide slowly, forming the acid. Boiling alcohol also dissolves it, from which it crystallizes on cooling into rhombic prisms. It absorbs ammonia, and is converted into an amide, thus: $C_2H_4CO_2 + NH_3 = C_2H_5CO_2NH_2$. The anhydrides of the dihydric dibasic acids are formed by the abstraction of water from the acid, either by substances having a strong affinity for water, or by heat: thus succinic acid, $C_2H_4(COHo)_2$, gives off OH_2, and becomes $C_2H_4(CO)_2O$, the anhydride. In the same way tartaric, malic, camphoric, and phthalic anhydrides may be obtained from the corresponding acids by heat or by distillation with phosphoric anhydride. When benzoyl chloride, C_6H_5COCl, acts on dry sodic succinate, a mixture of benzoic and succinic anhydrides is the result.

Mixed anhydrides may be obtained by using the benzoic, cuminic, &c., oxychlorides to decompose the dry salts of benzoic, salicylic, cinnamic, cuminic, &c., acids: thus, by decomposing dry sodic cinnamate with benzoyl chloride, benzo-cinnamic anhydride is obtained, thus:

$$C_8H_7CONao + C_6H_5COCl = NaCl + \left\{\begin{matrix} C_6H_5 \\ C_8H_7 \end{matrix}\right.(CO)_2O.$$

Benzo-cinnamic anhydride occurs in certain balsams, and is prepared from dry sodium cinnamate and benzoyl chloride, thus:

$$C_8H_7CONao + C_6H_5COCl = NaCl + \left.\begin{matrix} C_8H_7CO \\ C_6H_5CO \end{matrix}\right\} O.$$

After washing it is left pure, and is dissolved by alcohol, from which it crystallizes in small lustrous prisms, having an agreeable smell. Aceto-benzoic anhydride is prepared by heating dried sodium benzoate with acetyl chloride, thus:

$$C_6H_5CONao + CH_3COCl = NaCl + \left.\begin{matrix} C_6H_5CO \\ CH_3CO \end{matrix}\right\} O.$$

Or by acting on fused sodium acetate by benzoyl chloride, thus:

$$CH_3CONao + C_6H_5COCl = NaCl + \left.\begin{matrix} CH_3CO \\ C_6H_5CO \end{matrix}\right\} O.$$

Potassium acetate may be substituted for sodium acetate in this reaction. In the above reaction the group C_6H_5 CO takes the place of the Na in CH_3CONao to form this mixed or double anhydride. Other anhydrides are formed by similar substitution. When distilled it is resolved into acetic and benzoic oxides or anhydrides, thus:

$$\left.\begin{matrix} CH_3CO \\ C_6H_5CO \end{matrix}\right\} O + \left.\begin{matrix} C_6H_5CO \\ CH_3CO \end{matrix}\right\} O = (C_6H_5CO)_2O + (CH_3CO)O_2.$$

In the distillation the acetic anhydride passes off first, while the other crystallizes on cooling in the retort. It is decomposed by water at 100° into the constituent acids. This anhydride is a colourless neutral oily liquid, obtained by washing from the NaCl formed in the above reactions.

THE KETONES.

Ketones are substances derived from the acetic or fatty series of acids by the substitution of a monad positive radical, instead of the hydroxyl of the acid, thus: acetic acid, CH_3COHo, becomes CH_3COMe by the substitution of the radical CH_3, or Me, in the place of the Ho of the acid. CH_3COMe is termed acetone, and may be written $COMe_2$, which is a compound of carbonic oxide with the monad positive radical methyl. The ketones, therefore, are compounds of carbonic oxide with the radicals of the series C_nH_{2n+1}. The ketones bear a marked resemblance to the aldehydes, thus: CH_3COH is acetic aldehyde, and CH_3COMe is acetone, the acetic ketone, in which the radical Me supplants the H of the aldehyde; when the calcic or other diad salt of a volatile monobasic acid is submitted to dry distillation a ketone is one of the products formed, thus: $(CH_3)_2(CO)_2Cao''$ becomes converted into $COCao''$ and $COMe_2$. Most of the ketones, like the aldehydes, combine with the alkaline hydric sulphates, thus: $CH_3COMe + SOKoHo = SOKo Ho, CH_3COMe$. But, unlike the aldehydes, they do not reduce ammoniacal solutions of argentic oxide, and do not oxidize on exposure to the atmosphere. Nascent hydrogen converts the ketones into secondary alcohols, thus: $COMe_2 + H_2 = CH_3CMeHHo$, and the aldehyde $CH_3COH + H_2 = CH_3CH_2Ho$, the normal alcohol. The following are the most important ketones—viz., $CO(CH_3)_2$, $COCH_3C_2H_5$, $COCH_3C_3H_7$, $CO(C_2H_5)_2$, $COC_2H_5C_3H_7$, $CO(C_3H_7)_2$, $COCH_3C_4H_9$, $COCH_3C_6H_5$, $CO(C_6H_5)_2$, $(COEt)_2C_6H_4''$, &c. These ketones may be formed by distilling salts of the fatty acids, thus: $2\ C_nH_{2n+1}COKo = COKo_2 + CO(C_nH_{2n+1})_2$. Carbonic oxide acting on a sodic compound forms ketones, thus: $2Na(C_nH_{2n+1}) + CO = CO(C_nH_{2n+1}) + Na_2$. The zinc compounds of the monad positive radicals act on the chloracids of the same radicals, forming ketones, thus: Zn(C_n

$H_{2n+1})_2 + 2COC_nH_{2n+1}Cl = ZnCl_2 + 2CO(C_nH_{2n+1})_2$. Ketones containing two different radicals may be obtained by distilling two fatty acids, thus: $CH_3COKo + C_3H_7COKo = COKo_2 + COCH_3C_3H_7$. And zinc ethide acting on the chlorides obtained from the dibasic acid, forms ketones having a diad radical, thus: $(C_2H_4)''(COCl)_2 + ZnEt_2 = (C_2H_4)''(COEt)_2$. Acetone, $CO(CH_3)_2$, the best known of the ketones, is obtained by distilling calcic acetate or plumbic acetate with half its weight of quicklime, or by passing the vapour of acetic acid through a porcelain tube heated to redness. Sodic acetate, on ignition, yields acetone, thus: $2CH_3CONao = CONao_2 + CO(CH_3)_2$. Acetone is a colourless liquid, specific gravity ·79, having a pleasant odour, and boils at 56° C. The other ketones boil at temperatures that increase as the number of carbon atoms in the radical increases. Acetone burns with a clear white flame, and when heated gives off an inflammable vapour.

THE ALKALOIDS OR ORGANIC BASES—ANILINE (MAUVE, MAGENTA, EMERALDINE, ROSEINE, VIOLINE)—CAFFEINE, NICOTINE, QUININE, MORPHINE, STRYCHNINE, UREA, AND CYANIC ACID.

The alkaloids or organic bases form a large and important class of substances. They have been termed *alkaloids* because most of them, like the alkalies, exert a basic reaction on red test-paper; and *organic bases*, because, like inorganic bases, they combine with acids, forming salts. The inorganic bases are composed of two elements, while the organic are composed of three or four elements, of which nitrogen is an essential, with carbon, hydrogen, and often oxygen. They have been divided into the *natural* and *artificial*. The natural are found in plants and animals, and the artificial alkaloids are similar in composition and properties, and can be prepared by chemists.

The vegetable alkaloids contain carbon, hydrogen, and nitrogen, and most of them contain oxygen besides. They possess basic properties, and combine with hydrochloric acid and platinic chloride to form double salts, insoluble or difficultly soluble in water.

They possess alkaline properties, and neutralize the acids, forming crystalline salts; have generally a bitter taste, and form the active principles of tea, coffee, tobacco, opium, pepper, cinchona-bark, nux vomica, &c., in which they are found.

Of the animal alkaloids, guanidine and methyl-uramine contain carbon, hydrogen, and nitrogen; while others contain oxygen besides, such as urea, found in animal urine, and kreatine and kreatinine, found in the animal juices.

The artificial alkaloids consist of the amines and their analogues. These are monamines, diamines, triamines, and tetramines; and there are primary, secondary, and tertiary monamines and diamines. Then there are the phosphines, arsines, bismuthines, and stibines. For further information as to the nature of these artificial alkaloids the reader is referred to substitution products.

Most of the vegetable alkaloids are soluble in boiling alcohol, and assume the crystalline form on cooling. The plants containing the volatile bases are generally digested in weak alkaline solutions and distilled, when a portion of the ammonia comes over with the other products, which are neutralized with acid, evaporated, and digested with alcohol, which dissolves the basic sulphate. This sulphate is agitated with a strong solution of ether and potassic hydrate; the ethereal upper layer contains the volatile base, which is obtained by distillation.

The vegetable bases, when dissolved, may be precipitated by a solution containing tannic acid, such as decoction of oak-bark and leaves of the elm, chestnut, &c.—green tea and tincture of gall-nuts forming insoluble tannates, so that tannic acid is an antidote against poisoning by these bases. These bases are separated from the acids with which they are generally combined in the vegetable by adding water and hydrochloric acid or sulphuric acid to the vegetable matter, when the mineral acid displaces the vegetable acid and forms an easily soluble salt. And when an alkali or an alkaline earth is added, the organic base is precipitated and dissolved in boiling alcohol, from which it crystallizes on cooling.

Aniline, one of the most important of the artificial alkaloids, is largely prepared from the liquor obtained in gas-making from coal, which contains aniline in small quantities and benzol, together with various other substances. Nitric acid converts benzol, C_6H_6, into nitro-benzol, thus: $C_6H_6 + HNO_3 = C_6H_5NO_2 + OH_2$, and by distilling two parts of nitro-benzol, three of iron-filings, and two of acetic acid in metallic cylinders gradually raised to a red heat, $NH_2(C_6H_5)$, aniline, with other products, comes over, which are redistilled at a temperature between 170° and 190° C., when commercial aniline is obtained. It is also formed by the reducing action of sulphuretted hydrogen on nitro-benzol, thus: $NO_2(C_6H_5) + 3SH_2 = NH_2(C_6H_5) + S_3 + 2OH_2$. Other reducing agents have a similar effect. It is obtained by distilling indigo with a strong solution of potassic hydrate, when anthranilic acid is formed, which is heated in a retort, when aniline is condensed in the receiver. It is redistilled to obtain pure. The reaction is as follows—viz.: $C_8H_5NO + 4KHo + OH_2 = (C_6H_5)NH_2 + 2COKo_2 + 2H_2$. It is also formed by the distillation of nitro-toluol with lime, thus: $C_7H_7NO_2 + CaO = (C_6H_5)NH_2 + COCao''$. Aniline is a colourless thin oily liquid, having a hot aromatic taste and an agreeable odour. It is poisonous, a dozen drops being sufficient to kill a rabbit. It boils at 182° C., is very volatile, and does not freeze at $-20°$ C. When exposed to the air it assumes a resinous consistency and a brownish colour from the absorption of oxygen. It is slightly heavier than water, having a specific gravity of 1·028. It is soluble in water, and is dissolved in all proportions by alcohol and ether. Unlike the other alkaloids, it has no reaction on red test-paper. It forms with acid a large number of beautiful crystallized compounds. It can be distinguished from every other compound by the beautiful violet produced by mixing it with a solution of chloride of lime, and with chromic acid it yields a black, blue, or green precipitate. It has a high refractive power. It does not conduct electricity.

From aniline a large number of derivatives and substitution products are formed, which throw considerable light on the theory of organic chemistry. The sulphate of aniline is used therapeutically, and is prepared by saturating aniline with dilute sulphuric acid, evaporating to dryness, and extracting with boiling alcohol, which leaves the sulphate in white scales on cooling. Cyanogen combines with it directly, forming cyaniline, $(C_6H_5)NH_2(CN)$.

By substituting chlorine (or bromine) for the hydrogen in the phenolradical of aniline we obtain mono-, di-, and tri-chlorine anilines, $(C_6H_4Cl)NH_2$, $(C_6H_3Cl_2)NH_2$, and $(C_6H_2Cl_3)NH_2$ respectively. The basic character gradually becomes weaker until three atoms of chlorine replace three of hydrogen, when the compound becomes neutral.

Nitraniline has been produced by the replacement of one atom of H by NO_2. By far the most important application of aniline is in dyeing. The beauty, variety, and magnificence of the colours obtained from coal-tar is unsurpassed.

From aniline we obtain the well-known colours—purple, magenta, emeraldine, roseine, violine, &c.

Mauve, or *aniline purple*, can be prepared by mixing equivalent proportions of potassic dichromate and aniline sulphate, when a black precipitate is formed, dried and digested repeatedly with coal-tar naphtha until all resinous matter has been separated. The residue is dissolved by alcohol, transferred to a retort and distilled, when the purple is left behind.

Magenta, or *rosaniline*, can be prepared by the action of mercury nitrate on aniline, or by the action of stannic chloride, $SnCl_4$, on aniline. The liquid is boiled, water added and reboiled, and saturated with $NaCl$, when this colour is precipitated.

Emeraldine is prepared by acting on a mixture of aniline and hydrochloric acid with potassic chlorate to oxidize the aniline and produce a dark-green precipitate, which becomes olive-green on drying.

Roseine is prepared by adding two parts of plumbic peroxide, PbO_2, to one of aniline sulphate, and boiling. Filter and evaporate for some time, when resin separates, now add an alkali, when this substance is precipitated. Filter to separate the precipitate, dissolve in alcohol and evaporate, when a metallic-looking substance is left.

Violine is prepared by boiling two parts of sulphuric acid and one of aniline with some water, and adding some plumbic peroxide, reboil and filter hot. Boil the liquid with potash, filter off the precipitated colouring matter, wash with water, and dissolve in dilute tartaric acid. Filter and evaporate for some time, filter again and precipitate by an alkali, dissolve in alcohol and distil, when a bronze-coloured substance is left.

Caffeine, or *theine* ($C_8H_{10}N_4O_2$), may be extracted from tea or coffee by making a strong decoction in water, adding plumbic acetate, which forms a precipitate of plumbic caffeotannate. The lead is separated by passing SH_2 through the liquid. The caffeine is left in solution, which is concentrated, and it is crystallized from alcohol in long white silky needles. Or put a paper cone over a watch-glass on which there are some finely-powdered tea leaves, and heat over a spirit-lamp, when crystals of caffeine will condense on the cone. Caffeine occurs in tea to the extent of from two to six per cent. In coffee one per cent. is found, and in the kola-nut of Central Africa twice as much. However, the usual quantity in ordinary tea is between two and three per cent. It has a slightly bitter taste, and is inodorous. It is a volatile or essential oil, and not caffeine, that gives to tea its peculiar flavour and aroma. Caffeine contains almost 29 per cent. of nitrogen, about twice the amount contained in albumen. It appears from some experiments that the caffeine in tea causes the disintegration of the bodily tissues to be less than they otherwise would be. On this account it saves food to a certain extent. If about 7 grains of caffeine be swallowed it perceptibly quickens the circulation of the blood, excites the imagination, and produces a peculiar kind of intoxication, resulting in sleep. When caffeine is oxidized it is converted into amalic acid, $C_6H_7N_2O_4$, methylamine, and hydrocyanic acid. The changes that caffeine undergoes in the system are not definitely known. Boiling water and ether dissolve it largely, and alcohol and cold water sparingly. When heated it fuses, and it sublimes without decomposition. It forms crystallized salts with sulphuric and hydrochloric acids. It forms with argentic nitrate a compound which may be crystallized from boiling water. Strong nitric acid forms a yellow liquid, producing nitrous fumes, decomposing the caffeine; and when ammonia is added a fine purple colour is produced, and methylamine is eventually formed. When boiled with potash, methylamine is also produced.

The following table gives an approximate percentage composition of tea and coffee:—

	Tea.	Coffee.
Tannin,	16	4
Extractive matter,	20	35
Fibre,	20	
Gum,	8	9
Caseine,	15	13
Water,	5	12
Minerals,	5	7
Fat,	4	12
Caffeine,	3	1
Sugar,	3	6
Aromatic oil,	1	trace
Starch,	trace	trace.

Nicotine ($C_{10}H_{14}N_2$) is prepared by evaporating an infusion of tobacco in water to a syrupy consistency, and adding twice its volume of alcohol. The upper layer containing the salts of nicotine is decanted, evaporated to a smaller bulk, mixed with an alkaline solution, and agitated with ether, which dissolves the nicotine. The mixture is decanted from the surface, and oxalic acid in powder added, when an oxalate of nicotine is formed and falls to the bottom of the vessel. It is washed several times with ether, and the nicotine is separated by a solution of potash and ether. This solution is decanted into a retort, through which a current of hydrogen is transmitted. The ether and ammonia are expelled after being heated for a day to a temperature of 140° C., when the temperature is increased 40°, and the pure nicotine distils over.

Nicotine is one of the natural volatile oily bases, having no oxygen in its composition. It forms the active principle of the tobacco plant, being found in the roots, leaves, and seeds, forming from two to eight per cent. It is combined with citric and malic acids. It is a colourless oily liquid, having a specific gravity of 1·027 at 19° C., and boils at 250° C. It is very poisonous, one drop being capable of killing a dog. Ether and alcohol dissolve it readily, and water moderately. It is very inflammable, and burns with a smoky flame. When exposed to the air it absorbs oxygen, becoming brown and solid.

Nicotine may be written $\left\{ N(C_5H_7)''' \right\}_2$, in which C_5H_7 would represent the H_3 of NH_3, and this substance would therefore correspond with two atoms of ammonia, $(NH_3)_2$.

Iodine and chlorine, with nicotine, produce ruby-red and blood-red liquids respectively.

Nicotine forms white precipitates with salts of zinc, lead, and mercury, but with cupric salts it forms a blue solution. It combines with MeI and EtI.

Nicotine causes the plane of polarization of a ray of light to rotate *to the left.*

Quinine ($C_{20}H_{24}N_2O_2$) is prepared by boiling the pulverized bark of the yellow cinchona with ten times its weight of water acidulated with one per cent. of sulphuric acid, which dissolves the bases present. The liquid is strained, and when cold is treated with sodic carbonate, and the precipitate formed is submitted to pressure and the action of alcohol, which dissolves the bases. On cooling, the cinchonine crystallizes, and more is obtained by distillation, while the quinine remains in solution. The liquid is now neutralized by sulphuric acid, and the two bases, quinine and cinchonine, are separated by crystallization, the sulphate quinine crystallizing first, being least soluble, and the quinine is precipitated by adding ammonia to the sulphate.

Quinine can be separated from cinchonine by ether, which dissolves the former and not the latter. Quinine may be crystallized in silky needles by allowing its alcoholic solution to evaporate. It crystallizes with six atoms of water. It dissolves readily in alcohol, ether, and acidulated water, but is comparatively insoluble in water. It combines with acids, forming acid and neutral salts, of which the acid ones are most soluble. Of these salts the sulphate is the most important, as it is extensively used in medicine.

Both quinine and its salts have a very bitter taste. Quinine has a decided alkaline reaction. When ammonia is added to a mixture of chlorine, water, and a quinine salt, a green colour is observed. When distilled with caustic potash it yields quinoline, $N(C_9H_7)'''$, an oily base. The quinine salts give precipitates with oxalic, tartaric, and gallic acids and salts, and with argentic and mercuric nitrates.

When chlorine is passed through water in which quinine is suspended the alkaloid is dissolved, various shades of colour being produced. Quinine causes the plane of polarization of a ray of light to rotate to the left. The sulphate of quinine crystallizes in snow-white needles soluble in alcohol, and only to a slight extent in water.

When heated it fuses, emitting a phosphorescence. The acidulated solution exhibits the phenomenon of fluorescence. An acid sulphate is obtained by dissolving the sulphate in sulphuric acid and concentrating. It is soluble both in alcohol and water, and crystallizes in small needles. Iodine and the sulphate combine, forming flat plates, which polarize light. The sulphate is expensive, and is, therefore, liable to adulteration. It is adulterated with the sulphate of cinchona, which may be detected by adding ammonic hydrate and ether, when the cinchona floats between the two liquids and the quinine is dissolved.

Salicine, when present, produces a red colour when sulphuric acid is added. Stearic acid is detected by its insolubility in dilute sulphuric acid. Sugar, by being soluble in cold water and boracic acid, imparts a greenish tinge to the alcoholic flame. Chalk, gum, gypsum, magnesia, and starch, other adulterants, are insoluble in alcohol.

The citrate of iron and quinine is another preparation used in medicine, as well as the solution of the sulphate in tincture of orange-peel.

Morphine ($C_{17}H_{19}NO_8$) is the only one of the alkaloids of opium that is soluble in lime-water, and advantage is taken of this property to extract it from opium. An infusion of opium in water is boiled with milk of lime, which dissolves the morphine, leaving the other opium alkaloids and undissolved lime, which are filtered off. The filtered liquid is boiled and NH_4Cl added to neutralize the lime, when chloride of lime is formed, ammonia is dissipated by the heat, and the morphine is precipitated. It is purified by dissolving in HCl, adding milk of lime, and reprecipitating by sal-ammoniac, when morphine is deposited in short rectangular prisms containing two parts of water of crystallization. Or an infusion of opium is made in water and filtered, and the solution is concentrated and neutralized with chalk. A solution of calcic chloride is added which precipitates calcic meconate, while the hydrochlorate of morphine remains in solution. The meconate is filtered off and the liquid evaporated, when the morphine crystallizes out as hydrochlorate.

Morphine readily combines with HCl and CH_3COHo, forming the hydrochlorate and acetate, which are frequently used in medicine, especially the hydrochlorate, to induce sleep or allay pain. This alkaloid occurs in opium, together with narcotine, laudanosine, papaverine, codeine, meconic acid, &c. It is one of the principal narcotic constituents of opium, forming about one-tenth of it by weight. Boiling water dissolves twice the quantity that cold water does, in which it is sparingly soluble, and it is dissolved freely by alcohol, but not at all by ether. The morphine salts are crystallized readily, and are insoluble in ether, but soluble in alcohol and water. Morphine forms salts with methyl and ethyl iodides. Ferric chloride gives with morphine a blue colour; a mixture of H_2SO_4 and HNO_3 gives a green, and HNO_3 alone gives an orange colour. Tannic acid produces a bulky precipitate. Morphine changes the yellow colour of turmeric paper brown, and both it and its salts have a bitter taste. Like quinine, nicotine, and other alkaloids, it rotates the plane of polarization to the left. The hydrochlorate is its most important salt. It dissolves freely in water containing a little HCl, and in alcohol. It crystallizes in needles. Other salts used in medicine are the acetate and citrate. Lozenges are also made containing $\frac{1}{36}$th of a grain each of the hydrochlorate.

Strychnine ($C_{21}H_{22}N_2O_2$) is prepared by boiling rasped nux vomica in alcohol and water separately, when strychnine dissolved in water is obtained, to which magnesia is added, when the strychnine is set free, and is dissolved by boiling alcohol and distilled. It is then dissolved in dilute sulphuric acid, when a sulphate of strychnine is formed, and ammonia is added, when a sulphate of ammonia is formed, and the strychnine is precipitated. Or the ground seeds of the nux vomica are boiled with alcohol slightly acidulated with H_2SO_4, and neutralized with lime, which precipitates extraneous matters, while the bases remain in solution. The alcohol is dissipated, and the residue is treated with water slightly acidulated, and, on adding ammonia, strychnine with brucine is precipitated. These are converted into nitrates, and the nitrate of strychnine crystallizes first, leaving the brucine in solution. Strychnine forms about one-seventieth of the St. Ignatius bean, and it is obtained from nux vomica. The nux vomica is about an inch in diameter, round and flat, tough, inodorous, and intensely bitter. These seeds are imported from the East Indies. They are very poisonous —a few grains being sufficient to kill a dog, but it appears that it does not produce the same relative effect on different species of animals. The ground nut and extract are also used in medicine. Strychnine crystallizes from dilute alcohol in octahedra, but it is insoluble in absolute alcohol and ether. It is soluble in chloroform and the essential oils. Bromine and chlorine form substitution products that are still basic. A crystallized compound is formed when iodine is triturated with it, from which strychnine is obtained by the action of acids. When distilled with KHo it produces quinoline, $N(C_9H_7)'''$, a colourless basic oily liquid. It forms a compound with ethyl iodide. Strong HNO_3 turns pure strychnine yellow, but if brucine is present an orange-red colour is produced. When strong H_2SO_4 and potassic dichromate are added to a small quantity of strychnine a violet colour is produced, changing to rose. When a strong solution of sulpho-cyanide is added to a solution, crystals are formed immediately. And crystals are formed if tartaric acid is added to a solution of a salt of strychnine, and also hydric potassic carbonate. Sulphuric acid forms a neutral salt with strychnine; with auric chloride, $AuCl_3$, the sulphate or other salt gives a blue colour. Strychnine may be detected in cases of poisoning by rendering the liquid supposed to contain it alkaline, then agitate with chloroform, which will dissolve strychnine if present. On evaporation strychnine remains behind. It is taken up by

HCl, and tested by some of the characteristic reactions given above.

Urea, $CO(NH_2)_2$ or $\left\{\begin{array}{l}NH_2\\CO\\NH_2\end{array}\right.$, was originally prepared from urine by concentrating it, decanting from deposited matter, adding an equal bulk of pure strong nitric acid, when nitrate of urea is formed. Then the liquid is separated from the crystals, which are put in water to which baric carbonate is added, when baric nitrate is formed and urea is set free. The mixture of urea and nitrate after evaporation is treated with boiling alcohol, which dissolves only the urea, which is deposited on cooling in long colourless prisms. It is obtained by the action of carbonyl chloride on dry ammonia, thus: $COCl_2 + 2NH_3 = \left\{\begin{array}{l}NH_2\\CO\\NH_2\end{array}\right. + 2HCl$. It is prepared by mixing aqueous solutions of potassic cyanate and ammonic sulphate, when potassic sulphate and ammonic cyanate are formed. The ammonic cyanate is dissolved by alcohol, and urea crystallizes out on the cooling of the alcohol. It is also prepared by heating a mixture of carbonic ether, $(C_2H_5)_2CO_3$, and an alcoholic solution of ammonia to a temperature of 180° C. in a closed tube. From the formula $\left\{\begin{array}{l}NH_2\\CO\\NH_2\end{array}\right.$ it will be seen that urea is built up on the type of two atoms of ammonia, and is, therefore, placed among the amides, being a diamine. When pure and allowed to crystallize slowly it forms white four-sided prisms having a streaked glistening appearance, but when it crystallizes rapidly white silky needles are formed. It resembles saltpetre in colour and taste. It is inodorous and deliquescent. It is very soluble in water and alcohol, and sparingly in ether. When heated in a tube it is decomposed, evolving ammonia. The solution will keep for a long time in distilled water, and may be boiled without decomposition. This solution is neutral to test-paper. It melts at 120° C., and at a higher temperature it yields ammonia, ammonia cyanate and carbonate. When chlorine is passed into an aqueous solution of urea hydrochloric acid, nitrogen, and carbonic anhydride are formed. A strong aqueous solution of urea stirred with excess of strong nitric acid, on being allowed to stand, deposits nitrate of urea in scaly crystals. By substituting oxalic acid for nitric, crystals of oxalate of urea are formed. Mercuric nitrate produces a white precipitate in the same solution.

Cyanic acid ($CNHO$) can be prepared by heating urea with phosphoric pentoxide, or by heating cyanuric acid, Cy_3Ho_3. It can also be obtained by heating dry potassic ferrocyanide with binoxide of manganese, or by the oxidation of KCy. $CyKo$ is decomposed by strong HCl or H_2SO_4, with liberation of $CyHo$. Cyanic acid is a colourless thin liquid, having a specific gravity of 1·14 at 0° C., having a strong pungent odour. When mixed with water it breaks up into ammonia and acid carbonate, thus: $CyKo + 2OH_2 = NH_3 + COHoKo$. Cyanic acid readily changes into cyamelide, Cy_nHo_n, a white inodorous substance like porcelain. The cyanates are distinguished from the cyanides by not forming precipitates with the chlorides of iron and tin, and by the formation of a dark green precipitate of nitrate of copper. The cyanates of the alkalies, alkaline earths, and some of the metallic oxides are dissolved by water and are decomposed, ammonia being evolved. When potassic cyanate is decomposed by ammonic sulphate, ammonic cyanate is formed, and when the solution is concentrated urea crystallizes out. It is generally purified by recrystallization from alcohol.

ORGANO-SILICON, ORGANO-BORON, ORGANO-METALLIC COMPOUNDS.

Silicon, like carbon, is a tetrad element, and bears a considerable resemblance to carbon in its chemical behaviour, and in the complexity of the compounds which it forms. Like carbon, it can be obtained in three allotropic forms.

SiH_4 corresponds to CH_4, methylic hydride, and it is obtained by acting on magnesic silicide by hydrochloric acid, thus: $SiMg_2 + 4HCl = 2MgCl_2 + SiH_4$. And we have $SiCl_4$, $SiBr_4$, and SI_4 corresponding to CCl_4, CBr_4, and CI_4.

SiO_2 corresponds to CO_2, occurring in the form of quartz, &c.

Silico-formic acid, HSiOHo, corresponds to HCOHo, formic acid, and is obtained by the action of water on silicon chloroform.

Si_2Cl_6, Si_2Br_6, and Si_2I_6 correspond with similar carbon compounds.

And $SiHCl_3$, silicic chloroform, and $SiHI_3$ correspond with $CHCl_3$, chloroform.

Silicic oxalic acid, $(SiOHo)_2$, corresponds with $(COHo)_2$, oxalic acid.

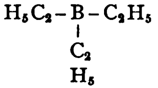
By the action of zinc methide on silicic chloride at a temperature of about 150° C. silicic methide is obtained, thus: $2ZnMe_2 + SiCl_4 = 2ZnCl_2 + SiMe_4$. It boils at 31° C. Its molecular weight is 88·5, and 1 litre of the vapour weighs 44·25 criths.

Silicic ethide, $SiEt_4$, is prepared by acting on $SiCl_4$ by zinc ethide, thus: $2ZnEt_2 + SiCl_4 = 2ZnCl_2 + SiEt_4$. It boils at 153° C. Its molecular weight is 144·5, and 1 litre of the vapour weighs 72·25 criths. Chlorine can be substituted for one or two atoms of hydrogen, producing siliconylic chloride, $SiEt_3C_2H_4Cl$ and $SiEt_3C_2H_3Cl_2$, which latter, when acted on by potassic acetate and alcohol containing water, produces disilicic oxyethide, $(SiEt_3)_2O$.

Silicic propionic acid, C_2H_5SiOHo, can be obtained by the following series of actions, viz.: $ZnEt_2 + 2SiClEtO_3 = 2SiEt_4O_3$, and $SiEt_4O_3 + 3CH_3COCl = 3CH_3COEto + SiEtCl_3$, and $SiEtCl_3 + 2OH_2 = EtSiOHo + 3HCl$.

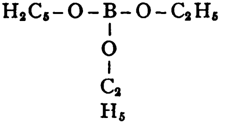
The following are some of the other silicon compounds that have been prepared, viz.: silicic methylate, $SiMe_4O_4$; silicic dichlorethide, $SiEt_2Cl_2$; silicic chlortriethide, $SiEt_3Cl$; silicic dimethylate diethylate, $SiMe_2O_2Et_2O_2$; silicic triethethylate, $SiEt_4O$; silicic triethohydrate, $SiEt_3Ho$; silicic chlortriethylate, $SiClEt_3O_3$; silicic ethylate, $SiEt_4O_4$; and siliconylic alcohol, $SiEt_3C(MeH)Ho$, boiling at 120° C., 129°, 144°, 145°, 153°, 154°, 156°, 167°, and 190° respectively.

The organo-boron compounds contain boron united directly or indirectly with the monad positive radicals. Thus in boric ethide



$$\begin{array}{rcl} H_5C_2- & B & -C_2H_5 \\ & | & \\ & C_2 & \\ & H_5 & \end{array}$$

the boron is united directly with the carbon of the radical, but in boric ethylate



$$\begin{array}{rcl} H_2C_5-O- & B & -O-C_2H_5 \\ & | & \\ & O & \\ & | & \\ & C_2 & \\ & H_5 & \end{array}$$

the boron is united indirectly with the carbon atoms. The organo-boron compounds are produced by the monad positive radicals methyl and ethyl replacing the methoxyl and ethyoxyl in methylic or ethylic borate.

Boric methide, BMe_3, is prepared by adding boric ether to an ethereal solution of zinc methide, thus: $3ZnMe_2 + 2BEto_3 = 3ZnEto_2 + 2BMe_3$. The molecular weight is 56, and 1 litre of the gas weighs 28 criths. It combines with NH_3, forming ammonia boric methide, thus: $BMe_3 + NH_3 = BMe_3NH_3$. Although the molecular weight is 73, yet a litre of the vapour weighs only 18·25 criths, one-fourth, instead of 36·5, the half, as is usual.

Hydrochloric or other acids, or cupric chloride, absorbs the ammonia from the compound, leaving the boric methide.

Boric methide burns spontaneously in the atmosphere, and is reduced to a liquid by a pressure of 4 atmospheres at a temperature of 10° C. Its molecular weight is 56, and 1 litre of the gas weighs 28 criths.

Boric ethide is prepared in the same way as the methide—that is, by the action of zinc ethide on boric ether, thus: $3ZnEt_2 + 2BEt_3O_3 = 3ZnEt_2O_2 + 2BEt_3$. Its molecular weight is 98, and 1 litre of the vapour weighs 49 criths. The liquid has a specific gravity of ·7, and boils at 95° C.

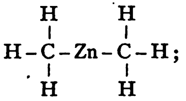
Like the methide it combines with ammonia, forming ammonia boric ethide, which is decomposed in the same way by acids, leaving boric ethide, thus: $BEt_3NH_3 + HCl = BEt_3 + NH_4Cl$.

Like the methide it burns spontaneously in the atmosphere with a green flame. When heated to 100° C. with HCl the chlorine takes the place of one atom of ethyl, which unites with the hydrogen of the acid, forming ethylic hydride, thus: $BEt_3 + HCl = EtH + BEt_2Cl$.

Oxygen converts boric ethide into boric binoxyethide, a colourless liquid, thus: $BEt_3 + O_2 = BEt_3O_2$, which boils at 125° C.

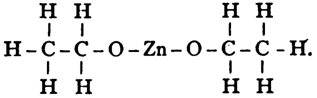
Boric binoxyethide is decomposed when distilled, and water converts it into ethylic alcohol and boric ethodihydrate, a white compound having a very sweet taste: $BEt_3O_2 + 2OH_2 = 2EtHo + BEtHo_2$.

The organo-metallic bodies contain a metal which is either directly or indirectly united to an organic radical. For instance, in zinc methide the zinc is directly united with the carbon of the radical, thus:



$$\begin{array}{ccccc} & H & & H & \\ & | & & | & \\ H- & C & -Zn- & C & -H; \\ & | & & | & \\ & H & & H & \end{array}$$

but in the ethylate the zinc is only indirectly united to the carbon through the oxygen, thus:



$$\mathrm{H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-O-Zn-O-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-H.}$$

A monad metallic element, such as sodium, unites with one atom of a radical, say ethyl, thus: $NaEt$.

A diad combines with two, thus: $ZnEt_2$.

A triad with three, thus: BEt_3.

A tetrad with four, thus: $PbEt_4$.

A pentad with five, thus: $AsEt_4Cl$.

The organo-metallic compounds may be formed by various methods, viz.: by the displacement of one metal by a more positive one, as mercury by zinc, thus: $HgAy_2 + Zn = ZnAy_2 + Hg$; by the action of a haloid compound of a metal on an organic compound of another metal, thus: $2ZnEt_2 + SnCl_4 = SnEt_4 + 2ZnCl_2$; by the action of a haloid compound of a radical on a metal, or an alloy with K or Na, thus: $2EtI + Zn_2 = ZnI_2 + ZnEt_2$, and $2MeI + SnNa_2 = SnMe_2 + 2NaI$.

Zinc methide, $ZnMe_2$, is obtained by sealing up methyl iodide with sufficient granulated zinc in a glass tube, and heating to a temperature of between 150° C. and 160° C., till the methyl iodide disappears. When the capillary extremity of the tube is broken the methyl escapes as a gas, and the liquid zinc methide may be obtained by distillation in an atmosphere of hydrogen.

Zinc methide is a transparent colourless volatile fluid. The molecular weight is 95, and 1 litre of the vapour weighs 47·5 criths. The specific gravity of the vapour is 3·3. The odour of this liquid is unbearable. It boils about 55° C., and is dissolved by ether.

In contact with pure oxygen it burns explosively, and in contact with the atmosphere it takes fire spontaneously, burning with a bluish-green flame. It decomposes water, forming methyl hydride and zinc oxide. It is decomposed by chlorine, oxygen, &c.

Zinc ethide, *$ZnEt_2$, is* obtained by heating to a temperature of about 130° C. ethyl iodide with granulated zinc in a sealed tube for about fifteen or sixteen hours, and the liquid is obtained in the same way as in the case of zinc methide—viz., by distillation in an atmosphere of hydrogen.

Zinc ethide is a transparent colourless liquid. Its molecular weight is 123, and 1 litre of the vapour weighs 61·5 criths. The specific gravity of the liquid is about 1·2, and it boils at 118° C.

Its odour is not so disagreeable as that of the methide. It takes fire spontaneously in contact with oxygen, burning with a blue flame, forming zinc oxide, but the action is not so violent as in the case of the methide. When the oxidation takes place slowly zinc ethylate is formed. The halogens decompose it with the formation of a zinc and ethyl compound with the halogen, thus: $ZnEt_2 + 2I_2 = 2EtI + ZnI_2$.

Water also decomposes it, thus: $ZnEt_2 + 2OH_2 = ZnHo_2 + 2EtH$.

It is dissolved by ether. It takes up one or two atoms of oxygen, thus: $ZnEt_2 + O = ZnEt_2O$ and $ZnEt_2O + O = ZnEto_2$. With stannic chloride it forms stannic ethyde, thus: $SnCl_4 + 2ZnEt_2 = SnEt_4 + 2ZnCl_2$.

With silicic chloride it forms silicic ethide, thus: $SnCl_4 + 2ZnEt_2 = SiEt_4 + 2ZnCl_2$. It forms a phosphine with phosphorous trichloride, thus: $2PCl_3 + 3ZnEt_2 = 3ZnCl_2 + 2PEt_3$.

Zinc ethide and ammonia form an amide and hydride, thus: $ZnEt_2 + 2NH_3 = 2EtH + Zn(NH_2)_2$.

When zinc ethide and ethylic oxalate are heated, and water added, ethylic diethoxalate is formed, thus: $ZnEt_2 + (COEto)_2 + 2OH_2 = CEt_3OCOHo + EtHo + ZnHo_2$.

It forms with nitric oxide zinc dinitro-ethylate, thus: $ZnEt_2 + 2N_2O_2 = (N_2OEt)_2Zno''$. With chlorether and ethylchlorether it forms zinc chloride, with ethylchlorether and diethylated ethylic ether, thus: $2(C_2H_4Cl)_2O + ZnEt_2 = 2(C_2H_4)EtClO + ZnCl_2$, and $2(C_2H_4)_2EtClO + ZnEt_2 = 2(C_2H_4Et)_2O + ZnCl_2$.

Mercury ethide, $HgEt_2$, may be obtained by the action of mercuric chloride, $HgCl_2$, on zinc ethide, thus: $ZnEt_2 + HgCl_2 = HgEt_2 + ZnCl_2$, or by the action of zinc ethide on mercuric ethiodide, thus: $ZnEt_2 + 2HgEtI = ZnI_2 + 2HgEt_2$. The mercuric ethiodide is obtained by the action of sunlight on ethylic iodide and mercury, thus: $EtI + Hg = HgEtI$.

Mercury ethide is a colourless, transparent, heavy, inflammable liquid. Its molecular weight is 258, and 1 litre of the vapour weighs 129 criths. It boils at 160° C. The halogens and acids cause it to lose one-half of its ethyl, thus: $HgEt_2 + HCl = HgEtCl + EtH$.

The following are some of the organic metallic compounds that have been prepared—viz., lithiomercuric ethide $LiHgEt_3$, lithic zincic ethide $LiZnEt_3$, sodic zincic ethide $NaZnEt_3$, potassic zincic methide and ethide $KZnMe_3$ and $KZnEt_3$, magnesic ethide $MgEt_2$, zincic methide $ZnMe_2$, zincic ethide $ZnEt_2$, zincic amylide $ZnAy_2$, zincic ethylate $ZnEto_2$, mercuric methide $HgMe_2$, mercuric methiodide $HgMeI$, mercuric methchloride $HgMeCl$, mercuric ethide $HgEt_2$, mercuric ethiodide $HgEtI$, mercuric ethchloride $HgEtCl$, mercuric ethnitrate $HgEt(NO_3)$, mercuric amylide $HgAy_2$, mercuric amychloride $HgAyCl$, mercuric amyiodide $HgAyI$, telluric methide $TeMe_2$, stannous methide $SnEt_2$, trimethyl arsine $AsMe_3$, triethyl arsine $AsEt_3$, triethyl phosphine PEt_3, methyl phosphine $PMeH_2$, dimethyl phosphine PMe_2H, ethyl phosphine $PEtH_2$, diethyl phosphine PEt_2H, trimethyl phosphine PMe_3, trimethyl stibine $SbMe_3$, triethyl stibine $SbEt_3$, triamyl stibine $SbAy_3$, triethyl bismuthine $BiEt_3$, cacodylic chloride $ASMe_2Cl$, stannic methide $SnMe_4$, stannic iododimethide $SnMe_2I_2$, stannic iodotrimethide $SnMe_3I$, hypostannic ethide Sn_2Et_6, stannic ethide $SnEt_4$, stannic diethodimethide $SnEt_2Me_2$, stannic ethodichloride $SnEt_2Cl_2$, stannic ethodiodide $SnEt_2I_2$, stannic triethobromide $SnEt_3Br$, distannic iodo-diethide Sn_2Et_2I, stannic phenyl triethide $SnPhEt_3$, stannic phenoethyldichloride $SnPhEtCl_2$, distannic ethodiiodide $SnEt_4I_2$, plumbic ethide $PbEt_4$, plumbic chlortriethide $PbEt_3Cl$, ethyl phosphoric iodide $PEtH_3I$, diethyl phosphoric zincic iodide $PEt_2H(ZnI)I$, triethyl phosphoric iodide PEt_3HI, tetrethyl arsenic chloride $AsEt_4Cl$, triethyl arsenic dichloride $AsEt_3Cl_2$, dimethyl arsenic trichloride $AsMe_2Cl_3$, methyl arsenic tetrachloride $AsMeCl_4$, tetrethyl antimonic hydrate $SbEt_4Ho$, antimonic triethoxide, $SbEt_3O$, &c.

THE IDENTIFICATION OF ORGANIC SUBSTANCES.

In the identification of organic compounds we require to take into consideration their physical characteristics, such as colour, odour, taste, or crystalline form, separately or collectively. For instance, the colour of indigo, or picric acid, and ferrocyanide, or ferricyanide of potassium, is characteristic, and so is the odour of carbolic or acetic acid, camphor, or alcohol. The taste of glycerine, sugar or the alkaloid is characteristic, and so is the crystalline form of many substances, such as urea or its salts, oxalic acid, or sugar. So that some substances can be identified at once by the colour or by the odour, or by the taste or by the form, or by one or more of these combined, but others cannot be identified by their physical characters, and we have to avail ourselves of the action of heat in the determination. The application of heat in heating up to a certain point in boiling, in evaporation, in heating in a tube open at both ends, or on platinum foil, or on a piece of porcelain, or by the blowpipe, or by any other means, often affords certain indications by which we may identify an organic substance. Heat breaks up most organic substances, leaving a black carbonaceous residue, and evolving an odour often characteristic of the substance operated upon. If the carbonaceous residue from an alkaline salt is soluble in water it indicates that the substance was an alkaline salt of an organic acid, and if insoluble it shows that an alkaline earthy base is present. The organic compounds containing the alkaline and alkaline earthy bases leave carbonates when heated, and the compounds with the heavy metals either leave the metal or an oxide of the metal.

The free organic acids are either volatile or non-volatile —that is, they can either be sublimed or distilled without or with decomposition. The fatty acids distil unchanged, while citric and tartaric acids, &c., suffer decomposition. The acetates on ignition are decomposed, producing acetone. Aniline, cinchonine, gelatine, albumen, morphine, quinine, urea, &c., give the odour of ammonia when heated in a small glass tube, and when heated on porcelain, and the heat continued until all the carbon is burned off, there will be a residue if the compound contains any metal except arsenic or mercury. Acetic acid, alcohol, aldehyde, aniline, butyric acid, carbolic acid, chloroform, ether, glycerine, lactic acid, nicotine, &c., on evaporation leave no residue.

Albumen, when heated up to 70° C., becomes milky, and when subjected to a higher temperature it coagulates.

Again, organic compounds have definite boiling-points, by which means we may often distinguish one compound from another. Thus the alcohols beginning with C_2H_5Ho, boiling-point 78° C., up to $C_8H_{17}Ho$, boiling-point 190° C., increase by a difference of about 19°. And the acids from CH_3COHo, up to $C_8H_{17}COHo$, increase from 118° C. to 254° C., with an average difference of 18°; but up to C_4H_9COHO the difference is approximately 22°. In the paraffine series, as the boiling-point increases from 1° C. for C_4H_{10} up to 124° C. for C_8H_{18}, the difference decreases.

Many substances like tartaric acid, when heated in a small tube, blacken, and give the odour of burned sugar. Others blacken and give the odour of singed hair, as uric acid, morphine, &c. Some give the odour of coal-tar, as cinchonine and quinine, while benzoic acid, &c., give an agreeable odour.

Formic and oxalic acids, when heated in a test-tube with strong H_2SO_4, give off CO without blackening, citric acid similarly treated gradually blackens and evolves CO, while tartaric acid blackens immediately. Again, re-agents are very useful for the identification of organic substances. For instance, brucine in the state of powder, moistened with strong H_2SO_4, gives a red colour, and some chlorine water and an excess of ammonia, added to a solution containing quinine, gives a green colour, and with a narcotine solution a reddish-orange colour would be produced. If a little potassic bichromate is added to strychnine, to which H_2SO_4 has been added, it will give a dark purple colour. A brown precipitate, with a solution of iodine, indicates an alkaloid, a blue precipitate indicates starch, a yellow, plumbic acetate, and no colour, a cyanide. Potassic or ammonic hydride gives a brownish red colour in a solution of gallic acid, and with tannic a brown colour. Ferric chloride, with meconic acid, gives a red colour, and the same colour is produced in solutions of acetic, formic, and hydrosulphocyanic acids.

Plumbic acetate gives a white precipitate with malic acid. Calcium chloride, in a neutral solution of tartaric acid, gives a white precipitate, and with citric acid no precipitate is produced until boiled. It also produces a white precipitate with a solution of oxalic acid, or an oxalate. It gives a white precipitate with neutral citrates, and gives a precipitate with malic acid, on the addition of alcohol.

Argentic nitrate gives white precipitates with neutral solutions of formiates and acetates.

Ferric chloride gives, with neutral solution of benzoic and succinic acids, brown precipitates.

Many organic substances dissolve readily in cold water —some dissolve moderately, or with difficulty, or not at all. Again, many substances that will not dissolve in water will dissolve in alcohol or ether, or in both, easily, moderately, or sparingly.

Cold or boiling water dissolves to a greater or less extent acetic acid, albumen, benzoic acid, brucine, butyric acid, caffeine, caramel, caseine, chloral hydrate, cholesterine, cinchonine, citric acid, cream of tartar, creosote, dextrine, formic acid, gallic acid, gelatine, glycerine, gum, hippuric acid, malic acid, meconic acid, morphine, narcotine, nicotine, oxalic acid, oil of bitter almonds, palmitic acid, picric acid, potash salts, pyrogallic acid, quinine, salicine, soda salts, starch, strychnine, succinic acid, sugars, tannic acid, tartaric acid, urea, uric acid, urates, &c.

Alcohol dissolves, to a greater or less extent, brucine, butyric acid, caramel, carbolic acid, chloroform, cholesterine, cinchonine, citric acid, creosote, formic acid, gallic acid, glycerine, lactic acid, malic acid, meconic acid, morphine, naphthaline, narcotine, nicotine, nitrobenzol, oil of bitter almonds, oleic acid, oleine, oxalic acid, palmitic acid, picric acid, pyrogallic acid, quinine, salicine, spermaceti, sugar, tannic acid, stearic acid, stearine, strychnine, succinic acid, tartaric acid, urea, wax, &c.

Ether dissolves to a greater or less extent benzoic acid, carbolic acid, chloroform, cholesterine, creosote, gallic acid, glycerine, hippuric acid, lactic acid, naphthaline, narcotine, nicotine, nitrobenzol, oil of bitter almonds, oleic acid, oleine, palmitine, paraffine, pyrogallic acid, quinine, spermaceti, tannic acid, &c.

If a substance is easily soluble when shaken in small quantities with cold water it cannot be albumen, benzoic acid, caseine, cinchonine, gallic acid, gelatine, gum, hippuric acid, morphine, palmitic acid, palmitine, paraffine, quinine, salicine, spermaceti, strychnine, starch, stearine, urates, or wax. This is negative evidence, which enables us to say that it is not one of a certain number of substances, but must be some other.

If the substance dissolve when heated in boiling water it cannot be albumen, caseine, palmitine, paraffine, spermaceti, stearine, or wax.

Again, there are substances which dissolve more freely in hot than cold water. For instance, caffeine is entirely soluble in boiling, but only slightly soluble in cold water. Chloral hydrate forms oily drops in cold water, but dissolves when the water is heated. And dextrine, gallic acid, gelatine, hippuric acid, soap, starch, or the nitrate and oxalate of urea dissolve in boiling, but not in cold water.

Again, aniline, benzoic acid, benzine, carbolic acid, cholesterine, meconic acid, narcotine, nitrobenzol, oil of bitter almonds, oleic acid, oleine, and stearic acid are very soluble in alcohol and ether, but slightly soluble, or not at all, in water.

Further, butyric acid, nicotine, and pyrogallic acid are soluble in water, alcohol, and ether; and indigo and starch are insoluble in water, alcohol, and ether.

Caffeine is soluble in boiling water and ether, but only sparingly soluble in cold water and alcohol.

Caramel is only slightly soluble in alcohol, but it is very soluble in water. Cinchonine is soluble in alcohol, insoluble in ether, and nearly insoluble in water.

Citric acid is insoluble in ether, and soluble in water and alcohol.

Morphine is soluble in boiling alcohol, insoluble in ether, and sparingly soluble in water.

Palmatine is soluble in ether, insoluble in water, and insoluble in boiling alcohol. Paraffine is soluble in ether, sparingly soluble in boiling alcohol, and insoluble in water.

Picric acid is readily soluble in alcohol, but only sparingly soluble in water. Quinine is sparingly soluble in water, and soluble in ether, but readily soluble in alcohol. Strychnine is scarcely soluble in water, and it is insoluble in alcohol and ether. Succinic acid is soluble in water and alcohol, but only sparingly soluble in ether.

Sugar is soluble in water, scarcely soluble in alcohol, and insoluble in ether. Tannic acid is soluble in water and alcohol, and sparingly soluble in ether.

Tartaric acid is soluble in both water and alcohol.

The solubility and insolubility of various compounds in certain reagents is one of the most important means for isolating compounds that are mixed together. If we have two compounds mixed together, and one is soluble in alcohol and the other is not, we put the substance in alcohol, which dissolves one and leaves the other. And on the evaporation or distillation of the alcohol we obtain the compound that was in solution in alcohol, it may be in the crystalline form. And in the same way we can isolate certain organic substances from others by water, ether, or other reagents.

Acetic acid is a colourless liquid, having an acid taste and the odour of vinegar. At 17° C. it crystallizes, and in this concentrated state it is known as glacial acetic acid.

It boils at 117° C., and suffers distillation unchanged, leaving no residue on evaporation. Its vapour on combustion yields CO_2 and OH_2.

Ferric chloride, when added in small quantity to an acid or neutral solution of acetic acid, gives a red colour that is not bleached by $HgCl_2$. When a substance contains this acid it gives the odour of acetic ether when heated with C_2H_5Ho and H_2SO_4.

It is soluble in water and alcohol.

The acetates are sold in the form of liquids or solids.

Acetates are decomposed on ignition, yielding $CO(CH_3)_2$. When heated with $CaHo_2NaHo$ they give CH_4, &c.

When a solid acetate is treated with strong H_2SO_4 and C_2H_5Ho it yields CH_3COEto. Free acetic acid is obtained when an acetate is distilled with dilute H_2SO_4.

Fe_2Cl_6 when added to an acetate produces a deep red colour.

Acetates are soluble in water.

Plumbic acetate, $Pb(CH_3CO_2)_2 + 3OH_2$, crystallizes in right rhombic transparent prisms, and usually consists of an agglomeration of acicular white crystals. It has an intense metallic sweet taste and a faintish odour.

When the crystals are heated on a slip of glass they melt and give off an inflammable vapour with a peculiar agreeable odour, and leave a red or yellow residue of carbon and globules of lead.

Fe_2Cl_6 gives a red solution of ferric acetate and a white precipitate of plumbic chloride. A solution of iodine in iodide of potassium gives a yellow precipitate.

On adding KHo till alkaline, and stirring, a precipitate is produced, which dissolves in excess of acetic acid.

It is easily soluble in alcohol, and soluble in water, which latter solution has a sweet taste.

Plumbic tribasic acetate, $3Pb(CH_3OCO_2)_2 + OH_2$, crystallizes in opaque needles; but is generally sold in solution, and has a sweet taste and an alkaline reaction.

On ignition acetone is produced. A piece of paper dipped in the solution burns like tinder.

On breathing into a test-tube containing a little of the solution, and shaking, a white precipitate of plumbic carbonate is formed, and common water added to it likewise renders it milky.

Ferric acetate, $Fe_2(CH_3CO_2)_6$, forms a solution of a deep red colour.

It produces acetone on ignition. When boiled with four times its volume of OH_2 it yields a brown precipitate of basic-ferric acetate.

HCl changes the deep red solution to a yellow

Potassic acetate, KCH_3CO_2, forms white anhydrous opaque masses, that are very deliquescent, having a faintish acetic odour.

On ignition it yields acetone, and leaves a carbonate. It fuses easily.

Fe_2Cl_6 gives a bright red colour. It is very soluble in water and alcohol.

Baric acetate, $Ba(CH_3CO_2)_2 + 3OH_2$ or $Ba(CH_3CO_2)_2 + OH_2$, occurs crystallized in rhombic or flattened prisms. On ignition it yields acetone.

H_2SO_4 gives a precipitate with the solution, and Fe_2Cl_6 gives the red colour. It is sparingly soluble in alcohol, and more soluble in cold than hot water.

Sodic acetate, $CH_3CONaO + 3OH_2$, forms moist rhombic transparent crystals.

The crystals easily fuse to fibrous gray masses, which on further heating yield acetone and a carbonate. If it is heated in the dry state with soda-lime, CH_4 is evolved.

The carbonate does not deliquesce in air like that of potassium. It gives the characteristic red colour with Fe_2Cl_6. It is very soluble in water.

The aluminic, ammonic, argentic, cupric, mercurous, &c., acetates have generally the same characters as the above, with peculiar characteristics of their own.

Albumen ($C_{72}O_{22}N_{18}H_{112}S$) consists of whitish yellow shining tasteless scales. When moist it is opaque and white, and when dry becomes translucent or transparent, yellow, and horny. When heated in a tube it swells up, blackens, and evolves a disagreeable odour. The solution in cold water is coagulated by boiling; it first turns milky, and coagulates about 70° C., becoming opaque and insoluble. When strong nitric acid is added and heated it is dissolved. Strong HNO_3 coagulates the solution in water. Millon's reagent imparts to it a bright red or rosy colour. KHo dissolves it when heated. When acetic acid is added gradually to a solution it produces a flaky precipitate, which is redissolved in excess of the acid. Strong HCl dissolves it slowly, giving a violet colour, and this solution furnishes syntonin. Creosote immediately coagulates it. Alcohol also coagulates it, but not if alkaline. Ether does not coagulate it. H_2SO_4 dissolves it, giving a reddish-brown colour. Metaphosphoric acid gives a white precipitate, and the soluble metaphosphates do so if acetic acid is added. Add to the solution about one-tenth of acetic acid, and the same of strong potassium ferrocyanide, when a precipitate will be produced. Take a large quantity of sodic hydrate and add a drop of cupric sulphate, then add a little of the solution and warm, when a violet colour will be produced. If AmHo is added to the boiled precipitate given by HNO_3, when cold it changes the yellow colour to orange. Albumen assumes the appearance of gum in cold water, and when pure it has a slightly acid reaction. It gives a left-hand rotation to a ray of polarized light. It is soluble in cold but insoluble in boiling water, alcohol, and ether.

Alcohol (C_2H_5Ho) is a colourless liquid, having a burning taste and a characteristic odour. It is inflammable and volatile. It has a specific gravity of ·81 at 0° C. It is neither acid nor alkaline.

When alcohol is heated with strong H_2SO_4 and plumbic acetate the odour of acetic ether is evolved. If mixed with bichromate of potassium, and a little HCl added, and then heated, the red colour will become green. It inflames readily, and burns with a pale flame when not too dilute. On evaporation it leaves no residue. At a temperature of $-110°$ C. it becomes glutinous. When burned it does not give much light, but much heat, and is converted into OH_2 and CO_2. When passed through red-hot tubes it is decomposed—the products varying according to the temperature. When heated with H_2SO_4 it may give olefiant gas, ether, or alcohol, according to the proportions in which they are mixed and the temperature. It boils at 78·5° C.

It dissolves many of the vegetable acids, most of the deliquescent salts, many gases, the hydrocarbons, the essential oils, the vegetable alkaloids, the resins, potassium, sodium, and their hydrates and sulphides, ammonia, bromine, iodine, carbonic anhydride, nitrous oxide, cyanogen, phosphoretted hydrogen, small quantities of sulphur and phosphorus, soaps, sugar, fats, and fixed oils. It is miscible with water in all proportions. By a gentle heat it can be expelled, leaving the substances held in solution in a pure state.

Chlorine converts alcohol into HCl, the aldehyde, chloral hydrate, and ethylic chloride. When oxidized it is converted first into aldehyde and then into acetic acid. It forms ethylates with sodium or potassium.

Chloroform is produced when it is distilled with chloride of lime. When treated with nitric acid, nitrous ether, and oxalic, glycolic, and glyoxalic acids, are produced.

Aniline $\{(C_6H_5)NH_2\}$ is a brownish or yellowish, almost colourless, oily liquid, having an odour like ammonia, and a hot acrid aromatic taste. It is poisonous. It has a specific gravity of 1·028. It has a high refractive power, and does not conduct electricity. If any, it has a slightly alkaline reaction.

It boils at 182° C., and does not freeze at $-20°$ C. On evaporation it leaves no residue.

It is soluble to a considerable extent in water, in which it sinks. It is very soluble in alcohol, ether, and wood spirits.

Solid mercuric chloride when heated with it gives a dark purple mass. An intense purple colour is produced by adding a solution of calcic chloro-hypochlorite to a little aniline shaken with water. It stains deal of a yellow colour. It combines with cyanogen, and forms compounds with bromine and chlorine. From aniline various colours are produced, as stated above.

Benzoic acid (C_6H_5COHo) forms crystals having a light feathery snow-white glittering appearance, having the odour of incense, and producing a hot sensation when some of the crystals are placed on the tongue, and an acid taste. Its molecular weight is 122, and 1 litre of the vapour weighs 61 criths. It fuses readily, and sublimes without residue. It melts at 121° C. and boils at 240° C. Its vapour burns with a smoky flame when heated on platinum foil. It sublimes when heated in a tube, forming acicular crystals, evolving an irritating vapour, and leaving no residue. It dissolves freely in water on adding a little KHo. Water dissolves it slightly, and alcohol and ether freely. The benzoates of the tetrad metals are the only ones not soluble in water.

When ferric chloride is added to the acid or neutral solution of benzoic acid, or a benzoate, it produces a pale yellow or brown precipitate of ferric benzoate. When HCl is added to an ammonia solution it is precipitated in feathery flakes. Calcic chloride gives no precipitate in solution, being soluble.

Plumbic acetate gives a white precipitate of plumbic benzoate in solutions of sodic or potassic benzoate. When heated with strong H_2SO_4 the acid does not blacken or evolve SO_2. Nitric acid has no action, but other dilute acids precipitate the acid from solutions of the benzoates in water.

Benzine (C_6H_6) is a colourless liquid having the odour of gas, but rather more agreeable. Its molecular weight is 78, and 1 litre of the vapour weighs 39 criths. The specific gravity of the vapour is 2·8 nearly, and that of the liquid is ·85 at a temperature of 15° C. It floats on water. It is neither acid nor alkaline. At the freezing temperature it solidifies into fern-like transparent crystals. It fuses at 5° C., and boils at 81°, evolving an inflammable vapour that burns with a bright smoky flame. The vapour is decomposed when passed through red-hot tubes, carbon being deposited. On evaporation it leaves no residue. It is easily soluble in ether, alcohol, acetone, wood spirit, and oil of turpentine, but is insoluble in water. Benzol dissolves fats, oils, camphor, wax, gutta-percha, and caoutchouc, and when hot it dissolves iodine, sulphur, and phosphorus. It is dissolved to a red liquid when added by drops to strong nitric acid, and when this solution is poured into a large quantity of water nitrobenzol is separated as a heavy oil. When benzol is acted on by bromine, monobrom-benzol (C_6H_5Br) is formed, and by further action two, three, four, or five atoms of hydrogen are displaced. Chlorine has a similar action. Sulphuric acid forms with it sulpho-benzolic and disulpho-benzolic acids.

Brucine ($C_{23}H_{26}N_2O_4 + 4OH_2$) appears as a white crystalline powder having a bitter taste, but it crystallizes in the monoclinic system as oblique rhombic prisms that are transparent.

When heated it fuses easily, giving off its water of crystallization. When it is distilled with potassic chromate and H_2SO_4 a liquid passes over that is inflammable, and that burns with a blue flame. When the red solution, with strong HNO_3, is heated, it turns yellow.

Alcohol and boiling water dissolve it, but not ether. It is more soluble in water than strychnine.

Strong H_2SO_4 gives a red colour when applied to the powder. Ammonia added to the HCl solution gives an oily precipitate that turns into crystals. A solution of iodine in potassic iodide gives, with the aqueous solution, a brown precipitate.

Butyric acid (C_3H_7COHo) is a colourless, thin, oily liquid, having the odour of rancid butter. It has a hot, biting, acid taste, and on the skin it produces a peculiar gnawing action. It has a specific gravity of ·98.

On evaporation it leaves no residue. It boils at 161° C., and is not solidified at $-20°$.

It is easily soluble in alcohol, ether, water, or sulphuric acid.

Calcic chloride, or HCl, when added to its aqueous solution causes the acid to form an oil on the surface. Butyric ether, smelling like pine-apple, is formed when the acid is shaken with alcohol and H_2SO_4. Nitric acid forms with it nitrobutyric acid, and chlorine in the sunlight forms dichlorobutyric and tetrachlorobutyric acids. It forms salts with barium, calcium, copper, lead, silver, soda, &c.

Caffeine ($C_8H_{10}N_4O_2+OH_2$) forms fine white silky lustrous crystals, having a bitter taste, and no odour.

It fuses when heated in a test-tube, and sublimes without decomposition on the cool part of the tube in needles. It fuses at 234° C.

It is largely dissolved by ether and boiling water, but sparingly in alcohol and cold water.

When a crystal of chlorate of potash is added to a strong HCl solution a red residue is left on evaporation, which, when dissolved in Am Ho, gives a fine purple liquid that is bleached by KHo. When KHo is added until the solution is slightly alkaline there is no precipitate when stirred and set aside. For other reactions for identification see above.

Carbolic acid (C_6H_5Ho) forms long, moist, colourless needles, having the odour of coal-tar or wood smoke, like creosote, and has a hot taste. It quickly arrests all putrefactive and fermentative changes, and is very extensively used as a disinfectant. The liquid acid is brown, and has the smell of tar. Its specific gravity is 1·065. It is neither acid nor alkaline.

On evaporation it leaves no residue. It melts about 35°, and boils at 187° C.

It is dissolved easily by strong acetic acid, potassic hydrate, alcohol, and ether, but is sparingly soluble in water. When Fe_2Cl_6 is dropped into a solution in water it gives a dark purple colour, and it gives a red solution when dropped into strong nitric acid, and this solution, when boiled and cooled, gives crystals of picric acid. For further reactions see above.

Caseine ($C_{166}H_{264}N_{42}O_{52}S$) is white and opaque when moist, but, when dry, translucent, horny, and crystalline.

When heated it carbonizes and emits an offensive odour. Strong HNO_3 colours it orange, and dissolves it when heated. Strong HCl dissolves it when heated, giving a violet solution.

It is insoluble in boiling water, alcohol, and ether, but dissolves moderately in hot alcohol, and easily in saline solution — sal-ammoniac. And coagulated caseine is easily dissolved by solutions of alkalies and alkaline carbonates.

Acetic acid gives a flocculent precipitate with a solution, and in excess redissolves it. KHo dissolves it when heated. Millon's reagent imparts a rosy colour to the solution. When placed in water it slowly swells, becoming white and opaque.

When caseine is in solution it is coagulated at once by acids. Corrosive sublimate and cupric sulphate give precipitates with cold solutions of caseine. Rennet causes caseine to coagulate.

Chloroform has its physical characters, the results produced by the action of heat, its solubility, and the reactions with reagents previously given. It may be stated in addition that it should give no turbidity with $AgNO_3$, and that it should leave no residue on evaporation. It is neither acid nor alkaline.

Cholesterine ($C_{26}H_{44}O+OH_2$) is crystalline, transparent, and fatty, having an iridescent lustre consisting of very thin rhombic plates, having acute and obtuse angles of 79½° and 100½°, and by these angles it is characterized.

It fuses when heated to 145° C., and the vapour produced burns with a smoky luminous flame. No change is produced on boiling with KHo. On the evaporation of an ethereal solution with half the quantity of alcohol the crystals are deposited. The water of crystallization is dissipated by a heat of 100° C., when the crystals become opaque. It is not decomposed when distilled at a temperature of 349°. When boiled with HNO_3 cholesteric acid is produced. It is almost insoluble in water, and it is infusible in boiling water.

It dissolves in boiling alcohol, and crystallizes characteristically on boiling. It is easily soluble in ether.

There is a yellow residue when moistened with HNO_3 and evaporated—that is, changed to red—by ammonia. It gives a blue violet colour when moistened with strong HCl and a little Fe_2Cl_6 added, and evaporated to dryness. The alkalies have no action on it. Sulphuric acid decomposes it, forming cholesteriline.

Cinchonine ($C_{20}H_{24}N_2O$) consists of white brilliant striated, rhomboidal prisms, having a slightly bitter taste. Its salts are exceedingly bitter.

The solid fuses, giving off an odour like coal-tar. It fuses at 165° C. to a colourless fluid, which becomes a crystalline mass on cooling. When heated in a small tube it gives the odour of ammonia, and crystals are formed on the cool part of the tube. On heating after moistening with H_2SO_4 (dilute) it gives a red coloured residue.

It is insoluble in ether, nearly insoluble in water, soluble in alcohol and alkaline solutions. It is not dissolved when ammonia is added in excess, and shaken with ether. It does not dissolve when KHo is added to water, but when HCl is added it is soluble.

When chlorine water and afterwards ammonia are added it does not give a green colour like quinine.

When dissolved in as little HCl as possible, and potassic ferrocyanide added, a yellow precipitate is produced, which dissolves on warming with slight excess of the latter, and on cooling crystals are formed.

A brown precipitate is formed when a solution of iodine in iodide of potassium is added to its aqueous solution. The sulphate is its most important salt. When the solution in H_2SO_4 is heated with PbO_2 a red substance is formed. The solution in water is acid, and not astringent.

Citric acid ($C_3H_5O(COHO)_3 + 2H_2O$) consists of transparent rhombic colourless prisms having a pleasant acid taste.

When heated it loses water, then fuses, and is decomposed, blackening, and giving an odour like tartaric acid, but more pungent. When heated with strong H_2SO_4 there is a gradual blackening with evolution of CO. On ignition the alkaline citrates leave carbonates. The crystals melt when heated to 100° C., losing half their water. When heated with KHo it forms water, potassic oxalate, and acetate. When heated to 177° C. aconitic acid is one of the products obtained.

Citric acid is soluble in alcohol, very soluble in water, but insoluble in ether.

When ammonia is added in slight excess to the acid or neutral solution, filtered if necessary, and calcic chloride added, a precipitate is produced on boiling. When

KHo is added $CaCl_2$ gives a precipitate, which does not redissolve in excess of KHo.

Lime-water will give no precipitate until the solution is boiled.

By adding excess of KHo and potassic permanganate on boiling the colour becomes green. It forms three classes of salts, being tribasic. When AmHo is added to argentic citrate there is no mirror formed on heating. Ferric chloride gives no precipitate. Plumbic acetate gives a white precipitate. Strong HNO_3 turns citric acid into $CO_2(COHo)_2$, and CH_3COHo.

This acid and the soluble citrates, when present in solutions of ferric, aluminic, or some other metallic oxides, prevents ammonia from precipitating the metal.

By acting on this acid with hydrobromic acid, aconitic acid is produced, and when heated with hydriodic acid tricarballylic acid is obtained.

Formic acid has its physical characters, the results produced by heat, its solubility and its reactions with reagents given above.

Gallic acid ($C_6H_2Ho_3COHo + H_2O$) is a yellowish-white powder consisting of shining silky needles. Its solutions have a sour astringent taste and an acid reaction.

When heated it blackens, and when exposed to a temperature of about 212° C. it is entirely converted into CO_2 and pyrogallin, and when the temperature is raised about 36° the pyrogallin is decomposed into metagallic acid.

This acid is much more soluble in boiling than cold water. It is sparingly soluble in ether, but freely soluble in alcohol.

Ammonic or potassic hydrate gives a red brown colour that becomes darker on shaking. A little Fe_2Cl_6 gives a black colour when added to the acid or neutral solutions. It reduces the salts of silver and gold. A crimson solution is formed when this acid is mixed with about five times its weight of H_2SO_4, which, when dropped into water, deposits crystals of rufigallic acid. The alkaline gallates absorb oxygen from the air, becoming brown.

With Fe_2Cl_6 it gives a dark blue colour. Gelatine has no action on this acid.

Gelatine ($C_{16}H_{25}N_5O_6$) is a translucent, tough, and almost colourless or brownish-yellow mass, having neither taste nor odour.

When heated it blackens and gives off an offensive odour.

It is insoluble in ether and alcohol, and swells up in cold water, becoming dissolved when boiled.

It dissolves calcic phosphate to a considerable extent. It forms a viscid fluid in boiling water, and on cooling it forms a jelly.

Tannic acid gives a buff or yellow precipitate even with very dilute solutions. Mercuric or platinic chloride also precipitates it largely. An excess of alcohol gives a flocculent precipitate in aqueous solutions.

Potassic ferrocyanide, added to its solution in acetic acid, does not produce turbidity, as is the case with albumen. Strong H_2SO_4 converts it into leucine, glycocoll, &c., after remaining for some time in solution, and HNO_3 produces from it oxalic acid. By frequent boiling in water it loses the power of gelatinizing on cooling.

Glycerine, $C_3H_5(HO)_3$, is a neutral, uncrystallizable, syrupy, colourless liquid, without odour, and having a very sweet taste. Its specific gravity is about 1·25.

If distilled alone it becomes decomposed, but it can be distilled without alteration in a current of superheated steam. At about 4° C. it becomes gummy and nearly solid. It burns with a luminous flame when heated on platinum foil, and no residue is left. On evaporation no residue is left. It does not perceptibly alter when heated in a water-bath, thus differing from ordinary syrup. When heated with strong H_2SO_4 it becomes black, and gives off acroleine vapour that irritates the eyes.

It is sparingly soluble in ether, but very soluble in water and alcohol.

The oxides of barium, calcium, lead, and strontium are soluble in glycerine.

Nitric acid converts glycerine into glyceric acid. Sulphuric acid or phosphoric anhydride convert it into acroleine, and the latter, on taking up oxygen, becomes acrylic acid.

Potassic hydrate, when heated with glycerine, produces potassic formiate and acetate.

Under the influence of yeast, and a temperature of about 25° C. continued for a few weeks, glycerine is converted into propionic acid.

Hippuric acid ($C_8H_8NOCOHo$) forms milk-white or colourless shining prismatic crystals, having a slightly bitter acid taste and no odour. Plumbic hippurate crystallizes in shining four-sided tablets, and calcic hippurate crystallizes in fine rhombic prisms.

When heated it melts readily, and is decomposed, emitting an agreeable odour like bitter almonds, and leaving a residue of carbonaceous matter. When treated with H_2SO_4 it blackens more readily than benzoic acid, and emits more sulphurous acid. On boiling at 240° C. it becomes decomposed.

It is very sparingly soluble in cold water and in ether, but hot alcohol and boiling water dissolve it easily. It dissolves readily when a little KHo is added to water, and it is precipitated by HCl. Its compounds with the alkalies are very soluble.

Fe_2Cl_6 added to an acid or neutral solution gives a brown precipitate. On the addition of HCl a crystalline precipitate is produced. If the sulphuric acid solution be cooled and diluted with water, and boiled with excess of KHo, it gives off NH_3, differing from benzoic acid. Benzo-glycolic acid is produced by the action of nitrous acid on this acid. When this acid is boiled with nitric, oxalic, dilute sulphuric, or strong HCl, it is converted into glycocoll and benzoic acid. On boiling with KHo it is turned into glycocoll and potassic benzoate. When dissolved in strong HNO_3, and an equal bulk of H_2SO_4 added without increasing temperature, nitro-hippuric acid is formed, and is deposited in crystals on adding a large excess of water. Argentic and mercurous nitrate give with hippurates white insoluble precipitates.

Acroleine (C_2H_3COH) is a colourless transparent fluid, lighter than water, having a burning taste, and emitting an irritating vapour. It burns with a bright flame, and boils at 53° C. It is easily soluble in ether, and moderately soluble in water. It absorbs oxygen, becoming acid, and even when excluded from the air it becomes converted into a flocculent white substance. It forms a brown resinous substance when acted on by sodic or potassic hydrate. Argentic nitrate gives a curdy white precipitate which, when boiled, deposits silver. A white substance is formed when NH_3 is passed into the ethereal solution.

Benzonitrile (C_6H_5CN) is a colourless oil, having a hot taste and the odour of bitter almonds. It is slightly heavier than water. Its refractive power is 1·5. When heated with K in a sealed tube a carmine colour is produced. When heated it evolves an inflammable vapour that burns with a smoky flame. When boiled with KHo it is converted into ammonia and potassic benzoate. It boils about 190° C., and distils without decomposition. When heated with strong HNO_3 it forms nitro-benzonitrile, one atom of H being displaced. It is soluble in alcohol and ether, and is but sparingly soluble in water. It is dissolved by strong H_2SO_4.

Canada balsam is the almost colourless fluid-resin of the *Pinus balsamea.* It consist of about 73·4 of resin soluble in alcohol, 18·6 of an essential oil, and 4 of extractive matter and salts. When fresh drawn it is a transparent colourless fluid, after some time it becomes glutinous, and afterwards solid. It has a refractive index of 1·53, and turns the plane of polarization of a ray to the right. It has a characteristic odour, is ductile, and easily assumes the solid form. When distilled with water a volatile oil is produced. It is partly soluble in alcohol.

Caramel is a dark brown, slightly bitter, deliquescent mass. When heated in a tube it blackens and yields the odour of burned sugar. When heated above 215° C., CO, CH_4, $COMe_2$, CH_3COH, various hydrocarbons, and CH_3COHo, are formed. It forms a dark-brown solution in water, in which it is very soluble, and in strong alcohol it is slightly soluble. It is precipitated from its aqueous solution by excess of alcohol as a brown powder. Yeast has no effect on it. Strong H_2SO_4 blackens it.

Carmine ($C_{14}H_{14}O_8$) is a brittle, brownish-purple mass. It does not decompose until it is heated to 136° C. It is soluble in water and alcohol, and only slightly soluble in ether. HCl and H_2SO_4 also dissolve it when strong. KHo changes the colour of the aqueous solution to purple. Nitric acid decomposes it. The haloids decompose it, changing the colour to yellow. The stannic salts give a bright crimson colour with its solution. Plumbic and cupric acetates give a red precipitate with its solution.

Cerotic acid ($C_{26}H_{53}COHo$) is a constituent of bees'-wax. It crystallizes from its solution in small grains. It melts about 78° C., assuming on cooling a very crystalline appearance. It can be distilled without decomposition. When Cl acts on the melted acid, chlorocerotic acid is formed. It is soluble in alcohol. When $AgNO_3$ is added to a boiling alcoholic ammoniacal solution argentic cerotate is formed, and plumbic cerotate is precipitated when alcoholic plumbic acetate is added to a boiling alcoholic solution.

Chloral (CCl_3COH) is an oily colourless liquid, with a characteristic odour that has a tendency to cause the eyes to become watery. It has a specific gravity of 1·5. It has a greasy touch and taste. It boils at 94° C. With strong H_2SO_4 it distils without decomposition. When heated with strong HNO_3 it is converted into trichloracetic acid. When heated with lime, calcic chloride and CO are formed, and a similar reaction takes place when the vapour is passed over iron at a red heat. When heated with acetic anhydride to 150° C. diacetyl chloral hydrate is formed. It is soluble in water, alcohol, and ether. It dissolves the halogens, phosphorus, and sulphur. It unites with water, forming a crystalline hydrate. On standing it changes into a white tough mass. Alcoholic potash converts it into chloroform and potassic formiate. Potassium decomposes it, forming a resinous substance.

Chloral hydrate (CCl_3COHH_2O) is a white crystalline solid, having a penetrating odour. It crystallizes in monoclinic crystals. When heated with water it dissolves; when heated it melts and volatilizes. When heated with KHo and C_2H_5Ho a formiate is formed. When boiled with HCl and HCN an acid is formed as a syrup. When heated with an excess of syrupy glycerine from 100° to 200° formic acid, chloroform, &c., are yielded. In cold water it forms oily drops. It is decomposed by ammonia, yielding chloroform. Strong H_2SO_4 converts it into chloral.

Cinchonine sulphate $\{(C_{20}H_{24}N_2OSO_2H_2O_2)_2+2H_2O\}$ crystallizes in prisms which have a vitreous lustre and are transparent. When heated with strong HCl in a sealed tube for a few hours to about 148° C. crystals are formed that are insoluble in acids. The solid fuses, giving an odour like coal-tar, and leaving a fine red colouring matter. It melts about 100° C., and gives off two atoms of H_2O, leaving a fine red resinous substance. It does not dissolve when KHo is added to water, but dissolves on the further addition of HCl. It is more soluble in water and alcohol than quinine. It is insoluble in ether.

Citrate of iron, $2\ (FeC_6H_5O_7+3H_2O)$, forms a dark-brown fluid having a sweetish taste. When evaporated it forms bright resinous scales. On evaporating an ammoniacal solution a darkish yellow mass is obtained. Ferric citrate is soluble in water. Ferrous citrate is precipitated from its solution by alcohol. Potassic ferro*cyanide* gives the liquid ferric citrate a blue tinge.

Chloropicrin (CCl_3NO_2) is an oil, transparent and colourless, having an odour like oil of mustard, and a high refracting power. It has a specific gravity of 1·67. The vapour is not inflammable. It boils at 120° C., and can be heated to 150° without decomposition; but when passed through a tube red-hot it is decomposed, yielding chlorine, trichloride of carbon, and nitric oxide. When boiled with HCl, HNO_3, and H_2SO_4, no action is produced. When heated with K there is an explosion. It dissolves in alcohol and ether, but is sparingly soluble in water. KHo solution has no action, but the alcoholic solution forms potassic chloride and nitrate. AmHo has a similar reaction. Potassium forms the chloride and nitrate at the ordinary temperature.

Citrate of lime ($Ca_3(C_6H_5O_7)_2+4H_2O$) is a white powder, consisting of transparent minute needles. When heated on platinum it is blackened, leaving a residue of calcic carbonate. It dissolves in HCl. It is more soluble in cold than boiling water. It is soluble in AmHo. Ammonia gives a precipitate when boiled with the HCl solution.

Cream of tartar, or bitartrate of potash ($KHC_4H_4O_6$), is a white crystalline powder, formed of monoclinic snow-white prisms, having a sour taste. It is gritty when chewed. The solid gives the odour of burned sugar, and is blackened. When exposed to a red heat it yields carbon and potassic carbonate. It is sparingly soluble in cold, but more soluble in boiling water. It is insoluble in alcohol. It is soluble in HCl and H_2SO_4, and KHo and NaHo. The aqueous solution has an acid reaction.

Creosote ($C_8H_{10}O_2$), when pure, is a colourless oily fluid, but commercially it is of a delicate brown or yellow colour. It is highly refractive, and has a burning taste and an odour like smoked meat. It is slightly heavier than water. It boils about 204° C. It burns with a smoky flame, but does not readily ignite. It is sparingly soluble in water, but is freely soluble in alcohol, ether, acetic acid, benzol, phenol, and carbon bisulphide. It dissolves resins, oils, and with the latter it is soluble in glycerine. It coagulates albumen. It has very great antiseptic powers. It forms a crystalline compound with KHo. It imparts a blue colour to ferric salts. Iodine forms a brown liquid with it. Chlorine decomposes it with evolution of HCl.

Dextrine ($C_6H_{10}O_5$) is a transparent, yellow, brittle, tasteless solid, having a vitreous fracture. When boiled with dilute HCl it becomes converted into grape-sugar. It blackens when heated. It dissolves freely in wood spirit. It dissolves moderately in water at the ordinary temperature, and dilute alcohol. It is insoluble in absolute alcohol and ether. A solution of tannic acid does not precipitate it. Tribasic plumbic acetate does not precipitate it like gum. Iodine does not give a blue colour. It does not ferment with yeast. It produces a right-handed rotation on a ray of polarized light. It does not reduce cupric potassic tartrate on boiling. With nitric acid it gives oxalic acid only, thus differing from gum.

Fumaric acid ($C_4H_4O_4$) crystallizes in rhombic or hexagonal prisms, or in needles. It is acid in taste, but is without odour. At 200° C. it volatilizes without melting, subliming unaltered, accompanied with the anhydride and water. When heated in a sealed tube with HCl malic acid is formed. It is freely soluble in alcohol and ether, but only slightly soluble in cold, but readily soluble in hot water. Bromine combines with it, producing dibromo-succinic acid. When digested with sodium amalgam in water, succinic acid is formed. Oxidizing agents do not decompose it.

Gum arabic is a yellow, brownish, transparent, tasteless mass. It is a combination of gummic acid, $C_{12}H_{22}O_{11}$, with OCa, OK_2, and OMg, &c. When boiled with dilute H_2SO_4 it is converted into dextrine, and then sugar. When heated with strong HNO_3, tartaric, oxalic, mucic, and saccharic acids are formed. It dissolves in water. It is precipitated by tribasic plumbic acetate, different from dextrine. Oxalate of ammonia detects the presence of lime in gum arabic. A solution of gum arabic gives a left-handed rotation of a polarized ray. Alcohol and ether give precipitates in solutions. Yeast uninfluences it. Iodine does not alter the colour. Ammoniacal plumbic acetate gives a white curdy precipitate. Strong HNO_3 converts it into oxalic and mucic acids. Saliva and gastric juice do not act on it.

Indigo ($C_{16}H_{10}N_2O_2$) is a dark blue amorphous powder or crystalline purple scales, having a metallic lustre. It has neither taste nor odour. When heated it gives off violet vapours, having the odour of ammonia and aniline. It fuses at about 290° C. Aniline is obtained when indigo is distilled with potassic hydrate. When carefully heated it can be sublimed without decomposition. Indigo is insoluble in water, alcohol, or ether. Dilute acids and alkalies do not dissolve it. It is dissolved when heated with strong H_2SO_4 to about 60° C., giving a blue solution. Nascent hydrogen converts it into $C_{16}H_{12}N_2O_2$, termed reduced indigo, or indigo-white. Nitric acid changes the sulphuric acid solution to a yellowish brown. When treated with a mixture of grape-sugar, sodic hydrate, and boiling alcohol, it is converted into indigo-white. And when mixed with $CaHo_2$ and ferrous sulphate, and shaken in a corked tube, and set aside, the indigo becomes yellow, and when acidulated with HCl, after decantation, it changes to a greenish blue colour.

Lactic acid (see above). In addition it may be stated that, when heated in a retort, the crystalline lactide distils over. It dissolves in strong hot alcohol, from which the lactide crystallizes on cooling. The acid remains unchanged when heated in a water bath.

Malic acid, $CMeHO(COHo)_2$, forms a translucent syrupy mass, crystallizing in four or six sided acicular deliquescent prisms. It has a rather agreeable sour taste. Its solution is acid. At 180° C. it fuses, loses water, and is decomposed into fumaric and malaeic acids, which have a pungent odour, and the latter condenses on the cool part of the tube. The acid is converted into fumaric acid when heated with HCl, and also when kept at a temperature of 150° C. When heated with H_2SO_4 acetic acid is formed, and when heated with binoxide of manganese in addition, aldehyde is formed. By heating in sealed tubes with HI succinic acid is formed. When heated with potassic hydrate, potassic oxalate and acetate are formed. This acid is easily soluble in water and alcohol, and most of the malates are insoluble in the latter, but soluble in the former. When plumbic acetate is added to an acid or neutral solution a white crystalline precipitate is formed, which fuses and sticks to the tube when boiled. Ferric chloride gives no precipitate in a solution of the acid. Calcic chloride or hydrate do not give any precipitation. This acid prevents iron being precipitated from its alkaline solutions.

Meconic acid, $C_4HO(COHo)_3+3H_2O$, consists of crystals of brownish-coloured scales. The solid when heated gives the odour of burned sugar, and blackens. It is sparingly soluble in cold, but easily soluble in boiling water, alcohol, and ether. The alkaline meconates are soluble in water—with most other metallic meconates are sparingly soluble. When calcic chloride is added to a solution of this acid, containing an excess of ammonia, a white precipitate, soluble in acetic acid, is produced. Ferric chloride gives a red colour that is not bleached by mercuric chloride.

Morphine (see above for its principal properties). It may be stated additionally that on heating it blackens and gives the odour of singed animal matter. When heated with strong H_2SO_4, and stirred with a glass rod dipped in HNO_3, it gives a play of colours from green to brown. On adding a solution of iodine in potassic iodide to a hydrochloric solution a brown precipitate is formed. Add KHo to the dilute HCl solution till slightly alkaline, stir, and set aside, when there is a precipitate soluble in excess of KHo.

Morphine acetate is a crystalline and deliquescent substance that has an alkaline reaction. It crystallizes in tufts of needles. When heated it gives the odour of singed animal matter and blackens. When evaporated by heating, acetic acid is given off, and crystals of morphine are formed, or a resinous residue is left if evaporated quickly. It is soluble in water and alcohol. Morphine is precipitated when sodic carbonate is added and stirred. A potassic iodide solution of iodine gives a brown precipitate.

Morphine hydrochlorate is a crystalline and non-deliquescent substance. It crystallizes in silky fibres. It blackens and gives the odour of singed hair when heated. It is soluble in water, and is freely soluble in alcohol, and in water containing a little HCl. With addition of sodic carbonate morphine is precipitated on stirring. A potassic iodide solution of iodine gives a brown precipitate. A precipitate which acetic acid dissolves is produced when KHo is added till alkaline and stirred.

Naphthaline ($C_{10}H_8$) consists of transparent rhombic flaky crystals, having an aromatic biting taste, a coal-tar odour, a pearly appearance, and an unctuous touch. The specific gravity of the vapour and solid is respectively 4·53 and 1·15. It burns with a smoky flame. It sublimes in fine crystals at the ordinary temperatures. At about 80° C. it fuses in water. When boiled with KHo it remains unchanged. Sulphuric acid combines with naphthaline when heated with it, forming various compounds. It boils at 220° C. It is easily soluble in alcohol and ether, but insoluble in water. The fixed and essential oils also dissolve it. Nitric acid converts it into a variety of compounds at different temperatures. Chlorine also forms many compounds with it. After prolonged boiling with HNO_3 phthalic acid, $C_6H_4(COHo)_2$, and oxalic acid are formed.

Narcotine ($C_{22}H_{23}NO_7 + OH_2$) is a white crystalline substance, without taste (the salts are bitter), and having an alkaline reaction. The crystals are lustrous right rhombic prisms forming colourless acicular tufts. It fuses about 170° C., losing water. When heated much above this temperature it is decomposed. It is easily soluble in alcohol and ether, but is almost insoluble in water. It dissolves freely in chloroform. An orange-red colour is produced when strong chlorine water is added to the dilute HCl solution and ammonia in excess. A dark-red colour is produced when dissolved in H_2SO_4 and stirred with a glass rod dipped in HNO_3, which disappears when more HNO_3 is added. A dark-red colour is produced when ferric chloride is added to a strong H_2SO_4 solution. A mixture of strong HNO_3 and H_2SO_4 produces a bright red colour. A yellow precipitate is formed when a little bromine solution is added to a dilute HCl solution, which is dissolved on heating. When submitted to oxidation it is decomposed into opianic acid and cotarnine.

Nicotine (see above for the properties of this compound). In addition it may be stated that prismatic crystals are formed when the solution in water is acidulated with HCl and mixed with platinum bichloride. On evaporation it leaves no residue.

Nitrobenzol ($C_6H_5NO_2$) is a yellow oil, having a sweet taste, and an appearance and odour like oil of bitter almonds. It is neither acid nor alkaline. It has a specific gravity of 1·2. It boils about 215° C., and fuses at 3° C. On evaporation it leaves no residue. When at a temperature of about 3° C. it forms acicular crystals. It dissolves easily in alcohol and ether, but is insoluble in water. Aniline is formed when its solution in alcohol is saturated with NH_3 and SH_2, or by adding a bit of granulated zinc to the alcoholic solution treated with a little HCl, then excess of KHo is added after the hydrogen has been given off, and it is shaken with ether, which dissolves the aniline. Sodium amalgam and water converts nitrobenzol into azobenzol $(NC_6H_5)_2$ and the hydride $(NHC_6H_5)_2$.

Oleic acid ($C_{17}H_{33}COHo$) is a colourless or yellow oil without odour or taste. At 4° C. it forms a white, firm, crystalline, acicular mass. It floats on water. On evaporation an inflammable oily residue is left. When exposed to a temperature of 0° C. it forms acicular crystals. It does not give the odour of acroleine when heated. When strongly heated it splits up into sebacic acid, $C_8H_{16}(COHo)_2$, caprylic acid, $C_7H_{15}COHo$, and caproic acid, $C_5H_{11}COHo$. When heated with potassic hydrate, potassic palmitate and acetate are formed. It is soluble in ether, KHo, and alcohol, but insoluble in water. The alkaline oleates are soluble, other oleates are insoluble. Air has no effect on the solid, but it quickly changes the fluid to a brown colour. Nitric peroxide converts it into elaidic, $C_{17}H_{33}COHo$, a solid fatty acid. And when oxidized by nitric acid it is converted into many of the acetic and succinic series of acids. This acid forms with potash a soft soap, and with soda a hard soap.

Oleine ($C_{57}H_{104}O_6$) is a yellow or colourless inodorous oil. It floats on water. When heated it gives the odour of acroleine. An oily residue is left on evaporation. It forms acicular crystals at $-3°$ C. It is not so readily dissolved by alcohol or KHo as oleic acid. It is insoluble in water, but easily dissolves in ether. Nitric peroxide converts it into elaidine, a solid white fat. When exposed to the air it becomes darker, rancid, acid, and assumes a resinous appearance.

Palmitic acid ($C_{15}H_{31}COHo$) consists of white acicular tuft-like crystals, tasteless and odourless. It floats on water. When heated in closed vessels with potash lime it remains unaltered, and even when air is admitted little action is produced. It fuses in water when heated to 62° C. It can be distilled without decomposition. When heated it boils and evaporates, leaving no residue. When heated it burns like other fats. When heated with alcohols it forms compound ethers. It dissolves freely in ether and boiling alcohol. It does not dissolve in cold or boiling water, and is sparingly soluble in alcohol. The neutral alkaline palmitates are soluble in hot water, and gelatinize on cooling. When the aqueous solutions of the palmitate are largely diluted with water they are decomposed. It forms three compounds with glycerine. At ordinary temperatures chlorine has no action on it, but at 100° C. substitution products are formed. Palmitine ($C_{51}H_{98}O_6$) is a white scaly crystalline fat. It forms a wax-like mass on cooling after fusion. It fuses in water when heated to 63° C., and a modification of it fuses at 46° C. When heated it emits the odour of acroleine. It does not dissolve in water. It dissolves in ether and boiling alcohol readily.

Picric acid, $C_6H_2HO(NO_2)_3$, crystallizes in long yellow rectangular plates. The aqueous solution has a bitter taste, and stains the skin yellow. When heated it fuses to a yellow oil, or is sublimed or decomposed. When heated with a bleaching-powder solution an odour like that of oil of mustard is evolved. It is sparingly soluble in water, and readily soluble in alcohol and ether. It is soluble in strong HNO_3 and H_2SO_4. When KHo is added to the alcoholic solution a yellow crystalline precipitate is produced. The addition of water to the HNO_3 and H_2SO_4 solutions precipitates this acid. The solution of this acid permanently dyes silk of a beautiful yellow when treated with a mordant.

Potassic ferrocyanide ($K_4FeCy_6 + 3H_2O$) crystallizes in large yellow crystals. It blackens when heated, and gives the odour of singed hair. When heated on porcelain with the ordinary flame, and then with the outer blowpipe flame, there is a residue containing iron, which, when moistened with water and tested, gives an alkaline reaction. When ignited it fuses and breaks up into nitrogen, potassic cyanide, and iron carbide. When heated in the presence of oxygen or oxides it is converted into the cyanate. It is soluble in water. It bleaches a solution of iodine. Argentic nitrate gives a white precipitate, which is soluble in KCy but insoluble in AmHo. Ferric chloride gives the Prussian blue precipitate, and ferrous sulphate gives a light blue precipitate. Cupric sulphate gives a red precipitate. Oxidizing agents convert it into potassic ferricyanide. Strong H_2SO_4 gives carbonic oxide, ammonic, ferrous, and potassic sulphates.

Potassic ferricyanide ($K_6Fe_2Cy_{12}$) crystallizes in dark red-coloured crystals. On ignition it is decomposed into nitrogen and cyanogen, leaving a residue consisting of iron, carbon, KCy, K_4FeCy_6, &c. It is soluble in water. Alcohol, dextrine, sugar, starch, &c., are oxidized in the presence of an alkali to water and carbonic anhydride. Ammonia with it evolves nitrogen, and yields ammonic and potassic ferrocyanides. Phosphorus and sulphur are converted by it and KHo into phosphoric and sulphuric acids. $AgNO_3$ gives an orange precipitate, soluble in AmHo, insoluble in dilute HNO_3. Ferric chloride gives a brown tint, but no precipitate. Ferrous sulphate gives a blue precipitate.

Pyrogallic acid, $C_5H_5O(COHo)$, is a white or slightly brownish crystalline light powder, having a flaky appearance and a bitter taste. When heated it melts and emits an irritating odour. It is freely soluble in water, alcohol, and ether. Ferric chloride produces in the aqueous solution a fine red colour, and KHo produces an intense brown. Lime-water gives a purple, changing to a dirty brown colour. It decomposes many of the salts of platinum, gold, and silver. It is used in photography for development. With a boiling solution of tartar emetic it gives lustrous crystals.

Quinine (see above for properties, &c.). Quinine and its sulphate, when heated, give an odour like coal-tar. A fine red colour is produced, that disappears on adding excess of AmHo, when a little Br or Cl water is added to the HCl solution, and a few drops of ferricyanide of potassium and ammonia, drop by drop. Quinine and its sulphate do not dissolve on the addition of KHo to water, but dissolve on the further addition of HCl. A potassic iodide solution of iodine produces a brown colour. A precipitate is produced, which is soluble in acetic acid when KHo is added till alkaline and stirred. The sulphate will not dissolve even in boiling water until a little *HCl or H_2SO_4* is added.

Rochelle salt is a tartrate of soda and potash, and crystallizes in transparent rhombic prisms, having a taste like common salt. It melts about 78° C., and boils about 120° C., and at 215° a glutinous mass remains, the water being driven off. It dissolves in water. When rendered slightly acid by acetic acid and stirred a precipitate is produced.

Rosin is either brown or white. The brown consists of pinic and sylvic acids, and the white consists almost entirely of pimaric acid, which is deposited from its alcoholic solution in crystalline masses. When pinic acid is heated colophol̈ic acid is formed. Sylvic acid fuses at 127° C. When pimaric acid is melted and allowed to cool a crystal glass is formed. When rosin is boiled with nitric acid it is dissolved, and terebic acid is deposited in quadrilateral prisms.

Pinic acid is soluble in cold alcohol, which leaves it in an amorphous mass on evaporation. Sylvic acid dissolves in hot alcohol, from which it crystallizes in prisms. Pimaric acid is soluble in boiling alcohol and in ether. Potassic hydrate dissolves rosin. The solution of sylvic acid in ether expels CO_2 from the alkaline carbonates.

Salicine ($C_{13}H_{18}O_7$) is a white crystalline bitter powder. When boiled with dilute H_2SO_4 grape-sugar is formed, together with saligenin. It fuses when heated to 120° C., and above that temperature it is decomposed. When heated with KHo potassic salicylate and oxalate are formed. It is moderately soluble in water, soluble in alcohol, and insoluble in ether. Strong H_2SO_4 gives with it a blood-red colour, and HCl gives a granular precipitate. An ammoniacal solution of plumbic acetate gives a precipitate, but tannin or gelatine does not give a precipitate. Strong HNO_3 converts it into picric and oxalic acids. Chlorine forms three substitution products with it. When heated with potassic dichromate and dilute H_2SO_4, HCOHo, CO_2, and an essential oil are produced.

Soap consists principally of the salts of the bases potassium or sodium with oleic, palmitic, or stearic acids. These salts or soaps are formed by boiling oleine, palmitine, or stearine with the alkaline solutions. Ordinary soap easily dissolves in hot water or alcohol, which deposit the soap on cooling. Soda soap is less soluble than potash soap. Soap is insoluble in water containing more than ·25 per cent. of salt (NaCl). When KHo or NaCl is added to a soap solution the soap is separated.

Spermaceti ($C_{32}H_{64}O_2$) is a crystalline, pearly, translucent fat, having a brighter lustre than paraffin. It has a specific gravity of ·94. It can scarcely be said to have either odour or taste. When heated in water it fuses about 50° C., and when heated on porcelain does not, like stearine or palmitine, give the odour of acroleine. When boiled with KHo it does not saponify. When distilled it is decomposed into cetylene and palmitic acid. It does not easily dissolve in cold, and is insoluble in boiling water. It is insoluble in cold, but soluble in hot absolute alcohol. It is easily soluble in hot ether, from which it crystallizes on cooling. Potassic hydrate has little action on spermaceti, but when fused with half its weight of KHo at about 105° C. palmitic acid is formed.

Starch ($C_6H_{10}O_5$) is a white tasteless powder, which is prepared for sale in little columnar masses. The granules of starch vary in size from more than $\frac{1}{300}$th to less than $\frac{1}{3000}$th of an inch in diameter, and the form of these granules varies with the plant from which the starch is obtained. It is half as heavy again as water. When heated it blackens, and gives the odour of burned sugar. When boiled with a small quantity of water it forms a paste, but when a large quantity is used it forms a solution. The aqueous solution when boiled for some time with HCl produces grape-sugar. When heated to 160° it becomes dextrine, and at a higher temperature it is decomposed. When heated with dilute H_2SO_4 it is first converted into dextrine and then grape-sugar. When distilled dry CH_4 *and* CH_3COHo are produced. It is insoluble in cold water, alcohol, and ether. Iodine solution gives a fine blue colour, that disappears on boiling, and returns on cooling; but KHo destroys this colour. Bromine gives a beautiful orange colour. During the germination of seed starch is fermented into dextrine and grape-sugar. The saliva and pancreatic juice convert starch into sugar. Tannic acid solution gives a precipitate with a starch solution. It produces oxalic acid when oxidized by nitric acid, and when it is fused with KHo and OH_2 it yields potassic acetate, formiate, and oxalate.

Stearic acid ($C_{17}H_{35}COHo$) crystallizes in transparent rhombic colourless plates, that, after fusion, form a glistening wax-like crystalline white mass on cooling. It has neither odour nor taste. It fuses at 70° C. when heated in water. It does not give off the odour of acroleine when heated. When heated above its fusing-point it yields palmitic acid, &c. It burns with a luminous flame. It floats on water, in which it is insoluble, but dissolves easily in hot ether or boiling alcohol. Potassic hydrate dissolves it, forming a soap. The alkaline stearates are soluble in water and alcohol, but other stearates are insoluble. Sodic chloride (NaCl) separates the soluble stearates from their solutions. When excess of water is added to sodic stearate (hard soap) solution in water, the fluid is rendered turbid. Nitric acid converts it into suberic and succinic acids, and when acted on by a current of chlorine chlorostearic acid is formed.

Stearine ($C_{57}H_{110}O_6$) is a crystalline white fat. It fuses in water heated to 71° C. When boiled with KHo it produces an emulsion, and gradually dissolves, forming a soap solution. When heated on porcelain it emits pungent fumes of acroleine, and burns with a luminous flame. An absolute alcoholic solution of sodic ethylate when heated with stearine decomposes it, yielding glycerine and ethylic and sodic stearates. It does not dissolve in boiling water, but dissolves in boiling alcohol, from which it is deposited on cooling. It dissolves readily in hot ether. It does not alter when exposed to the atmosphere. An absolute alcoholic solution of ammonia does not act on it. Chlorine and bromine form substitution products.

Strychnine (see above for properties, &c.). It occurs in prismatic crystals without odour and colourless, or as a white powder. The crystals do not fuse when heated, but blacken and give off the odour of singed hair. It is scarcely soluble in water even when boiled. It is rather sparingly soluble in ordinary alcohol. When KHo is added to water it does not dissolve until HCl is poured in. In HNO_3 it forms a colourless solution. A potassic iodide solution of iodine added to an aqueous solution produces a brown precipitate. When KHo is added till slightly alkaline there is a precipitate which acetic acid dissolves. When a few particles of plumbic peroxide are stirred in a strong H_2SO_4 solution on white porcelain there is a purple colour produced, changing to red.

Succinic acid, $C_2H_4(COHo)_2$, crystallizes in large rhombic white plates. It has an acid reaction. It fuses at 178° C. and boils at 235° C. When heated it melts, decomposes, and emits vapours that cause coughing. It sublimes in lustrous needles when heated in a tube open at both ends. On ignition the succinates are decomposed, and the alkaline succinates leave a carbonate. It burns with a blue smokeless flame on porcelain. When distilled it splits up into the anhydride and water. When distilled with H_2SO_4 and MnO_2 it yields acetic acid. When boiled with HNO_3 no change is produced. It is soluble in alcohol, moderately soluble in ether, and more soluble in boiling than cold water, in which most of the succinates are soluble. Ferric chloride added to an acid or neutral solution gives a dark red brown precipitate. When mixed with excess of ammonia, and on the addition of baric chloride and alcohol, there is a white precipitate of baric chloride. Plumbic acetate gives a white precipitate. Nascent oxygen splits it up into water, CO_2, and

C_2H_4. $CaCl_2$ gives no precipitate with the acid or its salts. This acid can be converted into tartaric acid, which can be reconverted into succinic acid.

Sugar (cane), $C_{12}H_{22}O_{11}$, consists of oblique four or six sided rhomboidal prisms. Ordinary loaf-sugar is made up of a mass of minute transparent crystals. The crystals of sugar-candy are larger than those of loaf-sugar, because they are formed by a slower evaporation. The aqueous solution has a sweet taste. It has a specific gravity of 1·6. It fuses at 160° C., and on cooling forms barley-sugar, and when the heat is continued to 205° C. caramel is formed. When heated it blackens and gives the odour of burned sugar. When heated with strong H_2SO_4 it blackens quickly. Boiling a solution to which a few drops of HCl has been added gives grape-sugar. When heated it fuses, and on cooling assumes a transparent amber colour. When a solution is boiled for a long time fruit-sugar is formed, and afterwards grape-sugar. It is soluble in about one-third of its weight of water; it is almost insoluble in cold absolute alcohol, and it is insoluble in ether. Its solution dissolves metallic oxides such as barium, calcium, lead, &c., when boiled with them. Add a little cupric sulphate and KHo drop by drop to its solution, a blue precipitate is produced, which dissolves in excess of the alkali to a blue liquid, which, when boiled, changes to yellow and red. When excess of KHo is added to solution and boiled, a delicate light brown colour is given. Gold is reduced from its salts by boiling with sugar solution, and chromic acid and mercuric oxide are also reduced, but copper in alkaline solutions is not reduced. When oxidized it is converted into formic, acetic, and propionic acids. Under the influence of yeast it is converted into grape-sugar, which readily undergoes alcoholic, butyric, or lactic fermentation. The solution rotates the polarized ray to the right.

Sugar (grape), $C_6H_{12}O_6$, consists of minute square plates, forming hard warty-looking masses. It crystallizes with difficulty. It is two and a half times less sweet than cane-sugar. When heated it gives the odour of burned sugar, and blackens. When treated with strong H_2SO_4 it does not blacken so easily. At 100° C. it fuses, losing its crystalline water. At 205° C. it is converted into caramel, and at a higher temperature, like cane-sugar, it is converted into CO, CO_2, C_2H_4, CH_3COHo, CH_3 COH, $C_5H_4O_2$, &c. On heating an alkaline solution it is decomposed, melassic acid being formed. When boiled with the salts of gold, silver, and mercury it reduces them. It is soluble in its own weight of water and in dilute alcohol. It gives a precipitate with ammoniacal plumbic acetate. It forms with NaCl a crystalline compound. PbO_2 converts it into plumbic carbonate and formiate. Add a little cupric sulphate and KHo drop by drop to its solution, a blue precipitate is produced which dissolves in excess of the alkali to a blue liquid, which, when boiled, changes to yellow and red more rapidly than in the case of cane-sugar. When excess of KHo is added to its solution and boiled, a darker brown is given than in the case of cane-sugar. Sulphuric acid does not decompose it like cane-sugar, but forms with it sulpho-saccharic acid. It reduces copper in alkaline solution, which cane-sugar cannot do. It undergoes the alcoholic, butyric, and lactic fermentation by special processes. It exerts a right-handed rotation on a ray of polarized light.

Sugar (milk), $C_{12}H_{22}O_{11}$, consists of four-sided milk-white prismatic crystals, so that they feel gritty and crunch when pressed by the teeth. When heated to 140° C. one atom of water is expelled, and when heated to 205° C. the crystals melt, losing water. When boiled with dilute acids it is converted into fermentable sugar. It is less soluble in water than grape-sugar, and is insoluble in alcohol and ether. It reduces the salts of silver, copper, and mercury when its alkaline solution is boiled with them. It is precipitated from its solutions by ammoniacal plumbic acetate. With nitric acid it produces oxalic and mucic acids. It produces a right-handed rotation of the polarized ray. It is not susceptible of fermentation. It forms compounds with the alkalies, alkaline earths, and lead.

Sylvic acid ($C_{20}H_{30}O_2$) forms a white powder or is composed of transparent tubular colourless rhomboidal prisms having neither taste nor odour. It has a specific gravity of 1·1. It melts at 153° C., and when heated in a retort it forms a thin liquid, which on cooling becomes thick at 120° and syrupy at 110° C. When distilled it is not decomposed. When boiled with HNO_3 it is dissolved. When subjected to dry distillation it forms oils, resin, and water. It is more soluble in hot than cold alcohol or ether. It dissolves in H_2SO_4, acetic acid, acetic ether, and oil of turpentine. Water precipitates it from its H_2SO_4 solution, and HNO_3 decomposes it. Water gives a precipitate with the boiled solution in HNO_3.

Tannic acid, $(C_6H_4O_2)_2O(COHo)_2$, is a brownish or yellowish powder having an astringent taste but no odour. When boiled with dilute H_2SO_4 it is converted into grape-sugar and gallic acid. When heated to a temperature of 330° C. it splits up into metagallic and pyrogallic acids. It is easily soluble in water, it is soluble in dilute alcohol, and in ether it is scarcely soluble. An inky black colour is produced by adding ferric chloride to the acid or neutral solution. Dilute H_2SO_4 gives a white precipitate. Ammonic or potassic hydrate imparts a brown colour to the solution. Its aqueous solution absorbs oxygen from the air, and is changed into gallic acid. Its aqueous solution is coagulated by KCl. Nitric acid changes it into saccharic and oxalic acids. It forms a buff-coloured compound with gelatine.

Tartaric acid, $(CHHO)_2(COHo)_2$, exists as a white powder, or colourless transparent oblique rhombic prisms. When heated it fuses about 170°, and at a higher temperature it is converted into isotartaric and metatartaric acids; and at 190° it loses water, and tartralic and tartrelic acids are formed, and finally the anhydride is formed. When heated it melts, blackens, and emits a sweetish odour like burned sugar. When heated with strong

H_2SO_4 it blackens immediately, evolving CO. When heated with potassic hydrate, potassic acetate and oxalate are formed. The alkaline tartrates leave a carbonate when heated, and the heavy metallic tartrates leave an oxide. The salts of gold, silver, and platinum are reduced when boiled with a solution of the acid. It is very soluble in both hot and cold water; it is also soluble in alcohol. The alkaline tartrates are soluble in water, but other metallic tartrates are soluble with difficulty. Ferric chloride gives no precipitate with it or the tartrates. To the solution add a little KHo, so as to leave still acid, and stir on a slip of glass with a glass rod, and a crystalline precipitate will be deposited. Add ammonia in slight excess to the acid or neutral solution, and add $CaCl_2$, and stir when there is a precipitate; add a slight excess of acetic acid and potassic acetate, and stir when there is a precipitate. A precipitate of calcic tartrate is produced when lime-water is added in excess, soluble in AmCl. Plumbic acetate gives a precipitate soluble in AmHo. Hydriodic acid converts dextro-tartaric acid into succinic acid. Plumbic acetate, CaH_2O_2, $AgNO_3$, and KCl produce white precipitates.

Tartar emetic, $2(SbOKC_4H_4O_6)H_2O$, forms a white powder, consisting of hard white crystals. When heated it blackens, and gives the odour of burned sugar. When heated to 100° C. it loses water, and when heated to 200° C. it loses more water, becoming $SbOKC_4H_2O_5$. It readily dissolves in water. The aqueous solution gives a white precipitate on adding a drop of HCl. The addition of AmHo also gives a white precipitate. It acts as a violent poison. The alkalies give a precipitate, and SH_2 gives an orange precipitate.

Turpentine ($C_{10}H_{16}$) is a transparent, colourless liquid, having a disagreeable bitter taste, and a peculiar penetrating odour. It has a high refractive power. Its specific gravity is ·86. It boils at 160° C. It can be distilled without decomposition. When boiled with HNO_3 a great variety of compounds are formed. When distilled with water and chloride of lime chloroform is produced. It is insoluble in water, but is soluble in alcohol, ether, and oils. It dissolves caoutchouc, phosphorus, resin, and sulphur. When kept stoppered for some time the odour of ozone is produced. It causes a right-handed rotation of a polarized ray. HNO_3 has a powerful action on it. It takes fire when paper soaked in it is put into a vessel containing bromine or chlorine. It dissolves iodine, forming a green solution, but only a very small quantity of the halogen should be used, as the reaction is sometimes dangerous. When exposed to the air it absorbs oxygen, forming formic, carbonic, and acetic acids.

Urea nitrate ($CON_2H_4NO_2HO$) crystallizes in hexagonal prisms. The solid emits an odour like sulphurous acid. When heated to 140° C. it is decomposed. It is sparingly soluble in water, and alcohol, and nitric acid. It is more soluble in hot than cold water. To the aqueous solution add baric carbonate, and evaporate to dryness; add alcohol to dissolve the urea, and evaporate, when crystals of urea are obtained. When HNO_3 is added to a dilute solution of urea a crystalline precipitate is obtained.

Urea oxalate, $2CON_2H_4$, $(COHo)_2$, crystallizes in transparent long thin prisms. The solid evolves NH_3 when heated in a tube without blackening. It is almost insoluble in an aqueous solution of oxalic acid. It dissolves easily in water at the ordinary temperature. It is less soluble in alcohol than water. To the aqueous solution add baric carbonate, and evaporate to dryness; add alcohol to dissolve the urea, and evaporate, when crystals of urea are obtained. Excess of oxalic acid precipitates it from its aqueous solution.

Uric acid ($C_5N_4H_4O_3$) consists of minute scaly crystals or white powder, having neither taste nor odour. When heated with KHo, NH_3 is evolved, and there is a residue of potassic oxalate, and carbonate, and KCN. When heated it blackens, and emits the odour of singed hair. On platinum foil it burns without residue. When heated in H_2SO_4 it does not blacken much, but is dissolved with very little change. On dry distillation it yields urea, ammonic carbonate, hydrocyanic acid, &c. On heating a mixture of this acid and water, on addition of a little PbO_2 urea and oxalic acid are produced. It is very sparingly soluble in cold or hot water. It dissolves on boiling in dilute nitric acid; it also dissolves when heated with a moderately strong solution of KHo. It is nearly insoluble in HCl; it is insoluble in alcohol and ether. To the aqueous solution add HCl in slight excess, and on stirring there will be a white powdery precipitate produced. The potassic hydrate solution is precipitated on the addition of a slight excess of HCl. It is precipitated by allowing the H_2SO_4 solution to cool, and adding water. When this acid is heated with a drop of HNO_3 on a glass slip, and carefully evaporated, there is a red residue, which is changed to a beautiful crimson by ammonia vapour. Bromine, when passed into water in which the acid is suspended, converts it into urea, &c.

Valeric acid ($C_5H_{10}O_2$) is a colourless oily liquid that will float on water, and has the odour of valerian root, and a burning taste. Its specific gravity is ·94. When passed through a red-hot tube carbonic oxide and anhydride and hydrocarbons, C_nH_{2n}, are formed. On evaporation it leaves no residue. It boils at 175° C. It can be distilled without decomposition. When the valerates are heated with H_2SO_4 they give the odour of valeric acid. When boiled with HNO_3 for several days it is decomposed, nitro-valeric acid being formed. It is freely soluble in acetic acid, alcohol, and ether, but is only sparingly soluble in water. It dissolves in H_2SO_4. It is converted into the anhydride by the action of phosphorus oxychloride. Chlorine acts on this acid, displacing hydrogen. Chlorine and bromine form substitution products. When a current is passed through a solution of potassic valerate, tetryl and CO_2 are formed.

Wax is yellow or white, somewhat crystalline, glistening, solid or semi-solid, lighter than water. At a moderate warmth it is soft and pliable, and breaks with a crystalline fracture when cold. There are several kinds, such as bees'-wax, sugar-cane wax, Chinese wax, Brazilian wax, &c. Bees'-wax consists of ceroleine, cerotic acid, and myricin, and Chinese wax has the formula $C_{54}H_{108}O_2$, and the formula of spermaceti, an allied substance, is $C_{32}H_{64}O_2$. It fuses in water heated to about 70° C. When boiled with alcohol it is partly dissolved, and cerotic acid crystallizes out on cooling. When the cold alcoholic solution is evaporated on a water bath it leaves a greasy substance termed ceroleine, fusing at 28° C. It is scarcely affected when boiled with KHo. It cannot be distilled without decomposition, but yields various hydrocarbons. The cerotic acid is soluble in boiling alcohol. Ceroleine is soluble in cold alcohol and ether, and myricin is insoluble in boiling alcohol, but soluble in hot ether, but benzol dissolves it freely. It is dissolved by strong H_2SO_4. Myricin is saponified when boiled with an alcoholic solution of KHo. Succinic acid is produced when oxidized by HNO_3. Nitric acid bleaches bees'-wax, and chlorine forms a substitution product.

Bile in 100 parts contains 90·44 of water, 8 of biliary and fatty substances, including resinoid acids, ·85 of watery extract, chlorides, phosphates, and lactates, ·41 of soda, ·3 of mucus, including sulphur, according to Berzelius. Human bile is a dark yellow-coloured fluid having a bitter taste and a nauseous fragrant odour. It is essentially a soap formed by the union of soda with taurocholic and glycocholic acids. It has, when fresh, an alkaline reaction. It sinks in water, and when shaken therein it assumes the appearance of soap-suds. When acetic acid is added to bile, mucin is thrown down as a curdy precipitate. A purple colour is given when a little cane-sugar solution is added to diluted bile, to which strong sulphuric acid is added. Nitric acid changes the colour from yellow to green, blue, indigo, violet, red, and orange, back to yellow.

Blood ($C_{45}H_{40}N_6O_{15}$) in 1000 parts contains—

Water,	775·45
Globulin and cell membrane,	131·11
Albumen,	69·42
Hæmatin,	8·375
Extractive matter (urea, kreatin, &c., soluble in water),	3·27
Chlorine,	2·665
Sodium,	2·196
Fibrine,	2·025
Fat,	2·015
Potassium,	1·825
Phosphoric anhydride,	·663
Oxygen,	·535
Calcic phosphate,	·213
Magnesic phosphate,	·147
Sulphuric anhydride,	·091.

In the above composition are included small quantities of cholesterin, ammonia, nitrogen, carbonic anhydride, and hydrochloric, lactic, oleic, phospho-glyceric, and stearic acids. The blood has an alkaline reaction. The blood in vertebrate animals is a viscid fluid of a florid red or purple colour, according as it is arterial or venous blood. The blood has a characteristic odour. Its specific gravity is about 1·058. Freshly-drawn blood coagulates a few minutes after being drawn, a clot being formed, leaving the serum a pale yellow-coloured liquid. The fibrinogen of the liquor sanguinis, the fluid in which the blood corpuscles are suspended, acts on the fibrinoplastin of the corpuscles, and produces coagulated fibrin that entangles the corpuscles in its meshes to form the clot. There are two kinds of corpuscles in the blood—red and white. The red are to the white corpuscles as about 300 to 1. In man the red corpuscles are between $\frac{1}{3000}$th and $\frac{1}{4000}$th of an inch in diameter, and about $\frac{1}{10000}$th of an inch in thickness, while the white are between $\frac{1}{3000}$th and $\frac{1}{2000}$th of an inch in diameter, and almost spherical. The peculiarities of these corpuscles can be observed by transferring a drop of blood from the finger pricked by a needle to a glass slide, covering with the cover slip, and examining with a high power. The red corpuscles appear of a yellowish colour, and circular in one aspect and biconcave in another. They can be seen assuming the form of rouleaux, and no nucleus is observable. Hæmoglobin is the colouring matter of the red corpuscles. The white corpuscles can be seen to have a protuberant irregular outline, which is continually changing. They consist of a fluid containing granular matter and a nucleus. The crystals are reddish-brown rhombic prisms. They are obtained by rubbing to a powder a drop of blood evaporated to dryness with a particle of common salt, adding a drop of glacial acetic acid, putting on a cover slip, heat till bubbles appear, then allow to cool, and examine under the microscope. The oxyhæmoglobin crystals can be examined under the microscope by freezing the defibrinated blood of an animal by means of a mixture of salt and ice, and then thawing and keeping for a day in a cool place, when the crystals will be deposited. The coagulation of the blood is suspended at 0° C., is retarded by low, and accelerated at high temperatures not above 50° C., and takes place most rapidly at 40° C. In tropical countries there is very little difference in colour between the arterial and venous blood. The ordinary temperature of the blood is about 37° or 38° C. When the serum is heated it is converted into a nearly solid mass. When the blood is completely burned the inorganic constituents (about 8 parts in 1000) found in the ashes bear but a very small proportion to the organic matter. Of these the sodium, iron, and calcium salts are the most important. When heated the blood becomes dried. When the clot has been removed, and the serum, the fluid left behind, is heated up to 77° C., it becomes coagulated, forming a translucent jelly. When 1000 parts of blood are evaporated there is left about 210 of a solid residue. When H_2SO_4 is added to the blood its odour becomes more developed. The presence of alkaline solutions prevents the coagulation of the blood. When a drop of water is placed close to the cover slip over a drop of blood, the red corpuscles swell up; with a solution of $NaCl$ they become shrivelled, and with acetic acid the white corpuscles disclose granular matter and a granular nucleus. When the dark venous blood is shaken up with oxygen it becomes a bright scarlet colour. When fibrin is treated with dilute HCl it increases in bulk, becoming transparent, and when the acid is neutralized the fibrin returns to its normal condition. When blood serum is saturated by NaCl fibrinoplastin is obtained, and when hydrocele is saturated similarly fibrinogen is obtained. When fibrinogen is added to serum coagulation takes place. Dissolve hæmoglobin crystals in water, and examine by the spectroscope, when two absorption bands will appear, one towards the blue and the other towards the red.

Fibrin is a yellow horny substance when solid. It exists in solution in the blood. When some freshly-drawn blood is whipped with the feathered end of a quill it becomes attached in soft white elastic strings. When heated in a sealed tube with water to about 150° C. it is redissolved. When a sodic chloride solution is heated it coagulates. When boiled for a long time in water it becomes dissolved. It is soluble in dilute solution of potassic or sodic hydrate. When exposed to the air in a moist state it absorbs oxygen, and gives off CO_2, becoming putrid. The acetic acid solution is precipitated by potassic ferrocyanide. The coagulation of fibrin is prevented by the presence of certain potassic or sodic salts. It decomposes hydroxyl.

Gastric juice is a transparent colourless fluid, has an acid taste, and a peculiar odour. It contains a mixture of HCl, acetic, butyric, and lactic acids. It also contains sodic chloride and lactate, magnesic and calcic chlorides, and ferric and calcic phosphates, but pepsin is an essential constituent. It has a specific gravity of 1·02. In 100 parts there are about

Water,	99·0
Pepsin,	·3
Hydrochloric acid, &c.,	·1
Sodic and other chlorides,	·2
Solid *constituents,*	·4

Boiling does not produce turbidity. It may be kept for a long time at 38° C. without becoming putrid. When pepsin is boiled its action is destroyed. Warmth accelerates digestion, and cold retards or suspends. Boiling does not coagulate the peptones produced by digestion. Pepsin is insoluble in alcohol, but soluble in water. At a temperature of 37° C. pepsin in an acid solution dissolves coagulated albumen, rendering it incapable of coagulation by heat, and readily soluble in water. It possesses high antiseptic powers. Tannic acid and $HgCl_2$ give a precipitate with the aqueous solution of pepsin. Pepsin exhibits its powers of digestion only in acid solution, and any acid is sufficient. A solution of pepsin in HCl digests fibrin. HCl alone renders fibrin more bulky and transparent. Pepsin alone has no action on fibrin. When a solution of pepsin in HCl is boiled in it the action of the pepsin is destroyed. HNO_3 does not give a precipitate with peptones. When a solution of pepsin in HCl is added to fresh milk a bulky precipitate is produced, which will be digested, and the fluid again becomes milky, containing peptone.

Glycogen is an opalescent, tasteless, amyloid substance in solution. When boiled with dilute H_2SO_4 it yields grape-sugar. It does not reduce an alkaline potassic cupric tartrate on boiling. When Fehling's fluid is added to glycogen, to which saliva has been added and boiled, there is a yellow precipitate, showing the presence of sugar. It is not soluble in alcohol or ether, but is soluble in water. Any animal ferment—as saliva or pancreatic juice—readily converts it into sugar. HNO_3 converts it into oxalic acid. With basic plumbic acetate it gives a white precipitate. A dilute iodine solution produces a brownish-red coloration, disappearing on warming, reappearing on cooling. When saliva is added the appearance of the fluid changes, and iodine does not give the brownish-red coloration.

Milk is a white fluid that is opaque, odourless, and having a sweetish taste. When allowed to stand for some time the cream forms on the surface. The cream is a whitish-yellow, fatty, thick layer. When the cream is taken off the milk is of a bluish-white tint. When examined under the microscope milk appears clear, with fat globules suspended in it. The specific gravity of milk is about 1·030. In cow's milk there are in 100 parts

Water,	86·0
Caseine and extractive matters,	5·5
Sugar,	4·3
Butter,	3·5
Salts, various,	·7

Milk does not coagulate when boiled, but caseine, containing fat corpuscles, forms a film on the surface. When allowed to stand at the ordinary temperature for some days lactic acid is formed from the milk-sugar by fermentation, and this acid coagulates the caseine, forming curds. When milk is burned the ash contains in 100 parts about

28·4 of phosphoric acid,
23·5 of potash,
17·3 of lime,
14·0 of potassic chloride,
7·0 of soda,
4·7 of sodic chloride,
2·1 of magnesia,
·5 of ferric oxide.

When milk, to which KHo is added, is shaken with ether the fat is dissolved. Acetic acid dissolves the envelope of the fat corpuscles. When treated with dilute acetic acid the investing membrane of the fat corpuscles becomes visible. When milk is treated with acids the caseine is precipitated, but when the acid is neutralized by sodic carbonate the caseine is re-dissolved. When dilute HCl, containing pepsin, is added to milk, caseine is precipitated.

Saliva is a viscid opalescent fluid. It contains a peculiar organic principle, termed ptyalin. The saliva has a slight alkaline reaction. The saliva consists of a large proportion of water and of ptyalin, forming about one-third of the soluble salts. It also contains small quantities of salts of sodium, potassium, and calcium, including lactates, calcic phosphate, potassic sulphocyanide, salivary mucin, &c. When saliva is examined under the microscope the salivary corpuscles and the flat epithelial mucous cells can be seen. When saliva is boiled its action on starch is destroyed. A temperature of 37° C. is the most favourable for the conversion of starch into sugar by saliva. When a test-tube containing starch and saliva is placed in a freezing-mixture the action of the ptyalin is suspended. Saliva is soluble in water. Ptyalin has the property of converting starch into sugar. Acetic acid added to saliva precipitates mucin. Acids and alkalies destroy its action.

Syntonin is the condition assumed by the muscle fibrin myosin after death. It is an opaque, white, gelatinous mass. The acid and alkaline solutions are not coagulated when heated. When boiled in water it is coagulated. The solution in lime-water is not coagulated when heated. Dilute HCl and H_2SO_4, and dilute KHo and NaHo dissolve it. Coagulated syntonin is not soluble in the dilute HCl or KHo. It is precipitated by neutralizing the acid or alkaline solutions. Carbonic anhydride precipitates it from its alkaline solutions. It forms a gelatinous mass with strong CH_3COHo.

OILS—FIXED AND ESSENTIAL.

There are two classes of oils, the fat or fixed oils, and the volatile or essential.

The fat or fixed oils are glycerides, or compound ethers of glycerine, $C_3H_5Ho_3$, a tribasic alcohol, with stearic, oleic, and palmitic acids.

And these fats can be resolved by saponification into stearic, oleic, and palmitic acids and glycerine.

They have been termed fixed oils, because they cannot be distilled without decomposition.

The essential oils can be distilled without decomposition.

The fats, or fixed oils, are of animal or vegetable origin, some being solid, like suet; some solid and soft, like butter; and some fluid, as in the case of the oils.

In animals, fat is found in the omentum, under the skin, and round the kidneys. The fat of warm-blooded animals is generally solid, while that of cold-blooded animals and fish is liquid. The principal solid fats are butter, grease, lard, and suet, and the fluid animal fats are cod-liver, neat's-foot, sperm, and whale oils.

In vegetables, fat is found in the tissues of plants, and their seeds and fruits. Linseed contains 20 per cent., and rape seed twice that amount of fat. In animal and vegetable fats, a certain quantity of an albuminoid occurs that exerts an important chemical action on the fat when kept for any length of time. The fat is generally extracted by pressure from plants, and when the fat is solid at the ordinary temperature it may be obtained by boiling the portion of the plant containing the fat with water, and allowing to cool, when the fat will form a solid layer on the top of the water.

All fats and oils are lighter than water, the specific gravity varying between ·91 and ·94. When pure, and in the fresh state, they are without odour or taste, but on exposure to the air they become oxidized and acid, acquiring rancidity, a disagreeable odour, and a deeper colour.

Palm-oil, cocoa-nut oil, and nutmeg butter are solid vegetable fats.

The fluid vegetable fats, or oils, are divided into the drying and non-drying.

The drying oils, when exposed to the air in thin layers, absorb oxygen, becoming dry and solid, which renders them useful in the preparation of oil colours and varnishes. The non-drying oils are converted into elaidine by mercurous oxide, and they do not absorb oxygen. Linseed, and some other drying oils, when mixed with tow or cotton wool, absorb oxygen so rapidly as to take fire.

Linseed, poppy, walnut, hemp, and cod-liver oils are drying oils. And colza, olive, rape, and almond are some of the non-drying oils. Castor-oil is partly a drying and a non-drying oil, forming a link between these two classes.

The true or solid acids occur only as constituents of vegetable or animal fats. The acids, from lauric to melissic, are solid at the ordinary temperatures. They cannot be distilled without decomposition except in vacuo. They have little action on litmus, and no taste nor smell.

Oleic acid forms another group of the fatty acids. The acids from formic to capric are volatile, and can be distilled without change. They have a pungent odour, and are fluid and oily at the ordinary temperatures. They have a bitter taste, and redden litmus paper. They occur in vegetables and animals; for instance, formic acid is found in red ants, and valeric acid in the valerian root. They can be likewise obtained by the decomposition or oxidization of vegetable and animal substances.

The fats or oils, when strongly heated in air, burn alone, or by inserting wicks. Palmatine and stearine fuse between 46° C. and 71° C., being found chiefly in solid fats, while oleine is fluid at 0° C., and is found principally in fluid fats. The fatty acids may be procured by the injection of steam superheated to from 250° to 320° C. in heated fats. Heat is produced by the oxidation of drying oils. By heating the fats and oils with oxide of lead and caustic lime their saponification is effected; but little glycerine is produced, as there is little water to react on the glycyl, C_3H_5, when liberated from the fat. The fats are more fusible than the acids derived from them by saponification, but they harden more when exposed to low temperatures. The fats or oils are insoluble in water, soluble to a greater or less extent in alcohol, and easily soluble in ether, oil of turpentine, and benzol. They act as solvents for phosphorus, sulphur, &c. Saponification takes place slowly when fats or oils are mixed with an aqueous solution of the alkalies, but this action takes place immediately if the oil is dissolved in alcohol and mixed with an alcoholic solution of caustic potash at the boiling-point. An emulsion is formed when fats are shaken with an aqueous solution of gum, albumen, and other substances that increase the density of the water and render it viscid, the whole assuming a milky appearance from the suspension of globules of oil. Oils penetrate paper, rendering it transparent, and producing a greasy stain. Rancidity can be removed by shaking the oil in water containing magnesic hydrate. Glycerine is formed when saponification takes place. A plaster is formed by the combination of plumbic oxide with a fatty acid. Tartaric acid, or hydrochloric acid, separates the fatty acid from the oleate or stearate.

Butter consists of about 87 per cent. of the fat of milk, 10 of water, 1 of caseine, 1 of common salt, and $\frac{1}{8}$ per cent. of sugar of milk. The milk fat in butter consists of a mixture of oleine, much palmatine, stearine, and several other fats—as caproin, caprylin, and butyrin. When heated in a glass tube it melts, the water remains at the bottom, the curd on its surface with a little of the melted fat, and the top layer consists of a fluid like oil. Butter dissolves in alcohol. When the fats in butter are saponified they each yield glycerine and butic, caprylic, caproic, and myristic acids.

Grease is a general term applied to all fatty and oily substances having some solidity, as the various kinds of dripping, fat, kitchen-stuff, tallow, &c. It is used in the lubrication of the rolling-stock of railways, in the form of oil for the more delicate parts of the locomotive, and grease for the wheel-axles. The grease for the wheel-axles is an inferior sort, containing a little tar, dirt, and other impurities, that render it unfit for candle-making, &c. *Locomotive-grease* is, strictly speaking, a kind of soap, as there is a small quantity of soda used in its manufacture. It is made of animal fat, or the vegetable fats, palm-oil [illegible] oil. The ingredients for summer and winter grease are mixed in different proportions. Grease for summer use consists of water, tallow, palm-oil, soda, and sperm-oil in the proportion of three-fifths, two-ninths, one-eighth, one-[illegible], and one-eightieth respectively. And winter grease consists of the same materials in the proportion of two-thirds, two-elevenths, one-eighth, one-eighteenth and one sixty-sixth respectively. *Waggon-grease* is cheaper than locomotive, and is made of caustic lime and a resinous oil, tar, pitch-oil, fish-oil, cotton-seed oil, &c., may be used. *Horse-grease* consists of the fat of horses, imported chiefly from South America. It is a very oily fat, and it is used for lubricating machinery. *Bear's-grease* consists of purified veal-fat, hog's-lard, beef-marrow, spermaceti, almond-oil, and some scent. It is made up into pomades for the toilet. Real bear's-grease is scarce.

Lard is the melted fat of the pig. It contains stearine, oleine, and margarine, the oleine predominating. When pressed at a low temperature oleine and stearine are separated. The latter is used for making candles, and the former, under the name of lard-oil, is used for lubricating machinery. Lard, when pure, is without taste or smell, and is white and firm. The best lard is obtained from the fat surrounding the kidneys. When melted it should be transparent and clear, like water, and when heated to 100° C. there should not be a trace of deposited matter nor the slightest ebullition. With lard H_2SO_4 of specific gravity 1·64 gives a light-brown colour, and nitric acid of specific gravity $1\frac{1}{3}$ gives a very slight yellow.

Suet is the fat from the omentum and the kidneys of the ox and sheep. It consists of a mixture of animal fats, stearine predominating, forming about three-fourths of the whole. When suet is melted it forms tallow. It is white, soft, and almost colourless. It fuses about 40° C.

Cocoa-nut oil is obtained from the kernel of the cocoa-nut. It has a disagreeable odour and a mild taste. It is used in the manufacture of stearine candles and marine soap. On saponification it yields caprylic, caproic, rutic, myristic, palmitic, and lauric acids. It also contains oleic acid. The oil is obtained by pressure or boiling. In tropical countries it is liquid, but in colder countries it forms a solid butter-like whitish oil. It melts about 21° C. It dissolves in benzene, the fixed and volatile oils, and in ether and alcohol when heated. When treated for some time with nitric acid, succinic, suberic, adipic, anchoic, and pimelic acids, with nitrocaprylic and nitrocaproic acids are formed.

Palm-oil is obtained from the fruit by crushing it and boiling with water to separate from albumen. It is fluid in warm countries, but in cold it assumes the consistency of butter. It has the odour of violets and is of a golden-yellow colour. It is used for making candles and soap, and for lubricating machinery. It consists principally of a fat termed palmatin, which, when saponified with an alkali, yields palmitic acid. It soon becomes rancid, and its fusing-point rises from 28° C. when fresh to 38° C. when rancid. It is bleached when exposed to a high temperature in contact with the air, or by oxidation with potassic dichromate and H_2SO_4.

Linseed-oil is obtained from *Linum usitatissimum* by pressure or the application of heat. The seed yields from 18 to 27 per cent. of the oil. When cold-pressed and pure it is pale yellow, having a pleasant taste, but the article of commerce is usually amber-coloured, and its odour and taste are rather disagreeable. It has a specific gravity of ·94, and does not freeze at – 28° C. It contains margarine chiefly, and palmatine and stearine. It is used in making paints, varnishes, printers' ink, &c. When boiled alone, or with the oxides of lead or manganese, it dries more rapidly than the unboiled oil. Nitric acid of 1·22 specific gravity produces a yellow, and sulphuric acid of specific gravity 1·64 gives a green or yellowish-brown colour. By exposure to the air it becomes solid. The impure oil contains albumen, and soon becomes rancid on exposure to the air. When heated to about 350° C.

it takes fire. When submitted to dry distillation a colourless oil, having a bread-like odour, is obtained. This oil, when hot, dissolves sulphur, eventually forming a brown glutinous mass. This oil is about eight times more soluble in hot than cold alcohol. With the alkalies it forms a soap.

Cod-liver oil is a drying oil. It is extracted from the liver of the cod, ling, coal-fish, and other allied species. There are three kinds—the pale, the pale-brown, and the dark-brown. The pale oil is the purest, as the brown oils are more or less impregnated with putrefactive matters. The pale has a peculiar fishy taste and odour, and the brown varieties have a much more disagreeable taste and odour. It consists of margaric and oleic acids, combined with glycerine, and containing bromine, iodine, phosphorus, acetic acid, and the constituents of bile. It is only partially soluble in alcohol, but ether dissolves it easily. A drop of strong H_2SO_4 produces a beautiful crimson colour. Nitric acid and caustic soda, each of $1\frac{1}{3}$ sp. gr., give a red and dark-red colour respectively.

Poppy-oil is obtained from the seeds of the black poppy, which yields about 40 per cent. of the oil. This oil is used by soap-boilers and painters. It is not a good burning oil. Nitric acid of $1\frac{1}{3}$ sp. gr. gives a red, but when the sp. gr. is 1·22 an orange-yellow colour is produced. The oil has a specific gravity of ·92. It solidifies at $-18°$ C. It is very soluble in ether, and is four times more soluble in boiling than cold alcohol. With chlorine and bromine it forms substitution products.

Castor-oil forms a bond of union between the drying and non-drying oils, since it becomes hard by long exposure to the air. It is extracted from the seeds of the *Ricinus communis* by the crushing action of iron beaters on the seeds in bags. When pure, and obtained by pressure alone, it is of a slight yellow colour, but when impure it has a greenish or brownish tinge. It consists of a mixture of ricin-stearate, ricin-oleate, and ricinate of glyceryl. It is rather thick and viscid, and has an acrid disagreeable taste and a nauseous odour. It becomes solid at – 18° C. On exposure to the air it turns rancid. It has a specific gravity of ·97. In medicine it is used as a mild purgative. It is soluble in ether, and differs from the other fixed oils in being also soluble in alcohol. When saponified it yields ricin-oleic acid. Ammonia forms with it an amide, and nitric peroxide converts it into ricinelaidic acid. When distilled with caustic potash, sebacic acid, in the form of a potash salt, is produced, and hydrogen is liberated. When the oil is distilled, œnanthylic acid and aldehyde are formed. Sulphuric acid of 1·53 sp. gr. gives a dirty white, and caustic soda, sp. gr. 1·34, gives a white colour. A mixture of sulphuric and nitric acids produces a reddish-brown colour.

Colza-oil is obtained from the seeds of colza, a Brassica. It is of a yellow colour, and is almost odourless. It is much used for illuminating purposes. At 5° C. it approaches solidity, and has a specific gravity of ·91. It is soluble in boiling alcohol. It freezes at – 6° C. It is a mixture of two glycerides, which, on saponification, yield two acids.

Olive-oil is obtained by pressure from the ripe olives. An inferior oil is obtained by heating the residue, after pressure, with water, which is used in soap-making. It has a specific gravity of nearly ·92. When kept for some time it acquires rancidity, and when cooled below 0° C. it becomes partly solid. The solid constituent is margarine. Sulphuric acid of sp. gr. 1·64 gives a light green, and caustic soda of sp. gr. 1·34 gives a light yellow colour. The virgin oil, or that which comes off first by pressure, is termed *Florence* or *salad* oil. Olive-oil is largely imported into this country under the name of *Gallipoli* oil.

Almond-oil is extracted from the kernel by pressure. It solidifies at – 25° C. It has a specific gravity of nearly ·92. It is used for oiling the delicate machinery of watches, &c. It has a slight yellow colour, is odourless, and has a pleasant taste. It contains oleine principally.

It soon acquires rancidity. It is easily soluble in ether, and is more soluble in boiling than cold alcohol. When bitter almonds are macerated with cold water and distilled, benzoic aldehyde, C_6H_5COH, is formed by a fermentative action.

Sperm-oil is the fluid portion of the fat of the sperm whale. It has a specific gravity of ·87, and it becomes thick or semi-solid about 7° C. It has a disagreeable odour and taste, and is of a yellow colour. It contains palmatine, oleine, and valeric acid, and on saponification it yields glycerine. Nitric acid, sp. gr. 1·33, and sulphuric acid, sp. gr. 1·53, give a red, while caustic soda, sp. gr. 1·33, and syrupy phosphoric acid give a dark-red colour. Nitric acid, sp. gr. 1·2, gives a light-yellow colour.

Neat's-foot oil is a soft fat obtained from the feet and intestines of the ox. It is much used for dressing leather. It is also used by chemists in the determination of vapour densities. Nitric acid, sp. gr. 1·33, gives a light-brown, sulphuric acid, sp. gr. 1·64, gives a brown, and a mixture of these acids gives a dark-brown colour. Nitric acid and sulphuric acid of lower specific gravities, aqua regia, and caustic soda, give a yellowish colour.

Rape-oil is expressed from the seeds of the winter rape. It is yellow, and freezes just below 0° C. It has a density of ·91. Rape-oil is used for burning in lamps, for soaps, for leather and woollen stuffs, and for the lubrication of machinery. It yields oily hydrocarbons, acroleine, and a mixture of volatile fatty acids on dry distillation. These hydrocarbons, with chromic acid, give acetic and propionic acids, but with nitric they give additional butyric, valeric, caproic, œnanthylic, and caprylic acids. Pale rapeseed-oil, with sulphuric acid, sp. gr. 1·53, gives a pink, and when sp. gr. 1·64 a brown colour is produced. Caustic soda of 1·33 sp. gr. gives a dirty whitish-yellow colour.

Sesame-oil, $C_{10}H_{18}O_2$, is obtained from the seeds of the *Sesamum orientale.* It has a yellow colour, the taste of hemp, and is inodorous. It is a non-drying oil. Sesame-oil is used for burning in lamps, for soap-making, and for the adulteration of volatile oils and balsams. It does not become rancid so soon as many other oils. With chlorine and bromine it forms substitution products. Nitric acid produces a yellowish-orange, red, or dark-red colour, as the specific gravity of the acid is increased, and sulphuric acid produces a greenish colour.

The Essential Oils may be divided into the sulphur essences, the oxygen essences, the pure hydrocarbons, and those oils obtained by dry distillation and fermentation. The sulphur essential oils are principally obtained from cruciferous plants. They contain the radical allyl, $C_3 H_5$, and include the oil of mustard and the oil of garlic. These oils are also found in asafœtida, scurvy-grass, and horse-radish. The oxygen essential oils are solid or fluid. The solid ones are termed camphors. The fluid oils are found in cloves, cinnamon, chamomile, caraway, cajeput, aniseed, peppermint, fennel, lavender, rue, spiræa, and thyme. When most of these fluid oils are cooled stearopten separates. The pure hydrocarbons are generally fluid. They absorb oxygen, becoming oxygen oils and resins. They have a higher refractive power, a lower boiling-point, and a lower specific gravity than the oxygen oils. Oil of turpentine, cloves, caraway, chamomile, birch, bergamot, hops, elemi, lemons, juniper, orange, parsley, savine, and valerian, are pure hydrocarbons, and chiefly contain the semi-hydrocarbon as oil of turpentine, with an oxidized substance. The following oils with others have been obtained by dry distillation, fermentation, &c., viz.: oils of bitter almonds, centaury, milfoil, black mustard, plantain, &c. The volatile oils can be distilled without change. Their boiling-points are generally higher than water, but when heated with water they pass off with the steam. When these oils are cooled they generally separate into a solid, and a fluid consisting of elæopten and stearopten. The hydrocarbons are separated from the oxygen essential oils by fractional distillation. The essential oils are soluble in the same fluids as the fixed oils. The oxygen essential oils are more soluble than the pure hydrocarbons in alcohol and water. The essential oils by exposure to the air absorb oxygen and change into resins. The oil of mustard and oil of bitter almonds are produced by a species of fermentation. The volatile or essential oils are generally found ready formed in plants. They are believed to constitute their odorous principles. There are many of them, and they are mostly fluid; however, there are some solid, such as the oil of aniseed. They have a hot and irritating taste, and a penetrating and characteristic odour. They are generally lighter than water, but vary in specific gravity. When fresh they are almost colourless, but on exposure to air and light they darken; some, however, are blue and others green. They refract light strongly. They are inclosed in the minute cavities of plants, and are diffused in every part of the plant, but are especially abundant in particular organs. Thus they are found plentifully in the leaves of the Labiatæ and Myrtaceæ; in the seeds of the Umbelliferæ; in the petals of the Rosaceæ; in the rind of the fruit of the Aurantiaceæ, &c. They resemble the fixed oils in their being soluble in the same fluids, and in inflammability. They produce a greasy stain on paper, &c., which soon disappears. The essential oils are generally mixtures of two or more compounds, one of which contains oxygen, and one is a hydrocarbon and more volatile, acting as a solvent for the others. The natural oils winter-green, spiræa, and cinnamon have been artificially produced. Some are produced by the putrefaction or dry distillation of certain vegetable substances. The oil of mustard and the oil of bitter almonds are formed by a peculiar kind of fermentation.

Oil of aniseed is obtained from the seed of the anise by distillation with water, which yields about one-fiftieth of its weight. This somewhat syrupy oil is almost colourless, often slightly yellow, and has the same taste and odour as the seed itself. In medicine it is used to relieve flatulence. It is also used in the preparation of liqueurs, and as a condiment. It has a specific gravity of ·98. This oil consists of a hydrocarbon similar to oil of turpentine, and a solid oxidized compound having the formula $C_{10}H_{12}O$, anise camphor, which solidifies about 10° C., and forms upwards of three-fourths of this oil. When heated to 220° C. in a sealed tube in contact with soda-lime, an acid isomeric with cuminic acid is formed. It is soluble in alcohol, the solubility varying according to the specific gravity of the alcohol. With nitric acid this oil forms a series of compounds containing the radical $C_8H_7O_2$. It absorbs oxygen from the air, and loses the power of solidifying by cold. The camphor, when expressed from the oil and crystallized from alcohol, forms white, soft, shining scales, slightly heavier than water. They melt at 18° C., and boil about 220° C. Anise camphor forms a liquid compound with HCl; with chlorine and bromine it forms substitution products.

Oil of winter-green is a colourless or slightly yellowish oil, having an agreeable odour. It is methyl salicylate, having the formula $C_6H_4HoCO(CH_3)O$, and contains an oil of turpentine hydrocarbon, which is volatile, and boils at 160° C. It is slightly heavier than water, having a specific gravity of 1·18. It boils about 220° C. This oil is slightly soluble in water. The potassic salt, $C_6H_4KOCo(CH_3)O$, is easily soluble in water. Ferric chloride imparts a violet tinge to the solution in water. The potash salt is formed by acting on it with a strong cold solution of potash.

Oil of spiræa, C_6H_4HCOHo, contains an oil of turpentine hydrocarbon, and a camphor. It is obtained by the distillation of the flowers of the meadow-sweet with water. It has a specific gravity of 1·17. It boils at 180° C., and freezes at $-20°$ C. This oil is colourless, but on exposure to the air it becomes red. The potassic acid salt crystallizes in needles. With the alkalies it forms acid and normal salts. The acid potassic salt is slightly soluble in water, but soluble in boiling alcohol. The normal potassic salt is soluble in alcohol. Ferric chloride produces a violet colour that disappears on exposure to the air. The salts of silver, lead, barium, &c., give yellow precipitates with a solution of the potassic salicylide.

Oil of cinnamon consists of cinnamic aldehyde, C_8H_7COH, together with an oil of turpentine hydrocarbon, with cinnamic acid and some resins. It boils about 220° C., and has a specific gravity of 1·03. It is a colourless oil, having a fragrant odour. It is prepared by distilling the bark moistened with salt water, and drying with calcic chloride. When boiled with chloride of lime, calcic benzoate is produced; and when boiled with nitric acid, benzoic acid and benzoyl hydride are formed. Nitric acid combines with it, forming crystals. It absorbs oxygen from the air, forming solid resins. The aldehyde may be separated by means of an acid alkaline sulphite. Various resins are produced by the action of ammonia and H_2SO_4 on this oil. Iodine does not turn a cooled decoction of cinnamon blue on account of the presence of tannic acid (probably) that decolorizes the iodide of starch.

Oil of mustard consists essentially of allyl sulphocyanide, C_3H_5CNS. It is a colourless oil, having a penetrating odour, producing a flow of tears, and blisters the skin. It has a specific gravity of 1·01, and boils about 150° C. When the crushed seed of black mustard is moistened with water fermentation takes place by the ferment myrosin on myronic acid, and the oil is produced. The odour from scurvy-grass and horse-radish is due to the presence of allyl sulphocyanide. When heated to 120° C. in a sealed tube, with potassic sulphide, the essence of garlic is produced. It dissolves phosphorus and sulphur when hot. It is slightly soluble in water, but freely soluble in alcohol and ether. It absorbs oxygen from the atmosphere, becoming brown. It forms a compound with ammonia as a base. White mustard yields upwards of 30 per cent. of a yellow oil, almost odourless, having a specific gravity of ·92. With soda it forms soap and glycerine. A low temperature does not solidify this oil.

Oil of garlic consists essentially of allyl sulphide, $(C_3H_5)_2S$. It is a yellowish liquid, lighter than water. The pure allyl sulphide is colourless, and may be distilled without decomposition. It is dissolved by sulphuric or hydrochloric acids, when a purple or blue colour is produced. It is not decomposed by alkaline solutions. It precipitates gold, silver, platinum, &c., from their solutions, but not copper nor lead.

The *essence of asafœtida* contains allyl sulphide, but there is more sulphur present than there is in the oil of garlic. It cannot be distilled without decomposition. It evolves SH_2 spontaneously. The oil can be obtained by distillation with water. By adding $BaCl_2$ with excess of chlorine to water distilled from the gum resin, baric sulphate is formed, and the presence of sulphur determined. By adding mercury to this oil the sulphide of mercury is formed. It is very useful in medicine for flatulence, nervous debility, &c.

Oil of turpentine, $C_{10}H_{15}$, is a resin obtained from pines and some other trees when cut. Common turpentine is yielded by the *Pinus Abies*. Venice turpentine is yielded by the larch, and is a clear pale-yellow viscid substance. It has a bitter taste, and the odour of balsam. It has a specific gravity of ·86, and it boils about 160° C. The commercial oil consists of a mixture of isomeric hydrocarbons. It forms a large part of all oil-paints, and is of considerable utility in medicine and the arts. By heating in a closed vessel isoterebenthine and metaterebenthine are produced. The oil of turpentine is distilled without decomposition. When the fluid yielded by the pine is distilled with water common resin is left in the retort, while the oil passes over with the vapour of water. It is insoluble in water, floating on the surface. It is soluble in the essential and fixed oils, and also in alcohol and ether. It dissolves the resins, caoutchouc, sulphur, and phosphorus. By acting on this oil with H_2SO_4, terebene and colophene are formed. With HCl it forms $C_{10}H_{16}(HCl)_2$ and $C_{10}H_{16}HCl$. This oil forms with water various hydrates containing one, two, or three molecules of water. Ozone is produced when it is exposed to the air. By its oxidation formic and terebinic acid are produced. When distilled with chloride of lime and water, chloroform and CO_2 are produced. Much heat is produced when chlorine is brought in contact with this oil.

Oil of chamomile consists of an oil of turpentine hydrocarbon containing an oxidized substance C_5H_8O. There are two kinds, obtained from the *Matricaria Chamomilla* and the *Anthemis nobilis* respectively. The oil obtained from the former is of a dark-blue colour, and contains an oxidized oil, $C_{10}H_{16}O$, a camphor, and the oil derived from the latter is of a green colour. When C_5H_8O is heated with KHo, potassic angelate is formed. The oil is prepared by distillation with water. It has a specific gravity of ·91. It becomes yellow when kept for a length of time. It is useful as a tonic in medicine, &c.

Oil of birch consists of a mixture of several oils, one being the oil of turpentine. The bark of the tree when heated without free access of air furnishes a tar from which this oil is obtained. Its odour is pleasant, and it is used in the preparation of Russian leather. It is soluble in alcohol and ether. The oil of turpentine can be separated from this oil by fractional distillation. When the buds and young leaves are distilled with water this oil is also produced colourless, afterwards turning yellow on exposure to the air; having a sweet taste, becoming hot afterwards. It solidifies at – 10° C.

Oil of bergamot consists of an oil of turpentine hydrocarbon and $C_{15}H_{10}O_5$, a solid oxidized substance. It is expressed from the rind of an orange. It has a specific gravity of ·87. It has a light or brownish-yellow colour, having a bitter taste but agreeable odour. The vapour yields benzene when passed over red-hot lime. When treated with phosphoric anhydride $C_{10}H_{16}$ is formed. It forms a liquid compound with HCl.

Oil of hops consists of an oil of turpentine hydrocarbon and an oxidized substance, $C_6H_{10}O$, termed valerol. It is produced by the distillation of hop cones with water. It does not solidify at – 17° C., and it boils between 140° C. and 320° C. It has the odour of thyme. When dropped on KHo potassic valerate is formed, and the pure hydrocarbon is obtained. The air converts it into a resin. Lupulite, the bitter principle contained in the lupulin of hops, is a neutral uncrystallizable substance. It is soluble in alcohol and water, but sparingly soluble in ether. Half the weight of lupulin consists of a yellow resin that is soluble in alcohol and ether.

Oil of cloves consists of a hydrocarbon isomeric with oil of turpentine, containing eugenic acid, $C_9H_{11}COHo$. This oil is obtained from the flower-buds (cloves) of the *Caryophyllus aromaticus* by distillation with water. It has a specific gravity of 1·06, and a temperature of – 18° C. does not solidify it. Eugenic acid is a colourless liquid having the odour of cloves. The salts with sodium and potassium crystallize. The oil also contains caryophyllin, $C_{10}H_{16}O$, and eugenin, both crystallizable substances, and isomeric with camphor and eugenic acid respectively. Eugenic acid boils at 242° C., and is soluble in the alkalies, alcohol, and ether, and it is sparingly soluble in water. The hydrocarbon passes off when the crude oil is distilled with a potash solution. It boils at 143° C., has a specific gravity of ·92, and is very refractive. The eugenic acid is reddened by nitric acid, and requires a further test to distinguish it from morphine. It forms crystalline salts with the alkalies, giving with ferric chloride a blue colour.

Oil of caraway consists of an oil of turpentine hydrocarbon termed carvene, containing carvol, $C_{10}H_{14}O$. The seeds of the *Carum Carvi* produce this oil, which has a specific gravity of ·94. Carvene is an oil lighter than water, without colour, having an aromatic taste and a pleasant odour. It crystallizes with HCl, the crystals melting at 50° C. Carvol is isomeric with cuminic alcohol and thymol. It is a liquid boiling at 225° C., and it has a specific gravity of ·95. Sulphuretted hydrogen and hydrochloric acid form $(C_{10}H_{14}O)_2SH_2$ and $C_{10}H_{14}OHCl$ with it respectively. The latter is a liquid camphor, and the former consists of crystals.

Oil of cubebs is obtained by distilling the fruit of *Cubeba officinalis* with water. This oil is colourless, somewhat glutinous, and has an aromatic taste. It has a specific gravity of ·93. It boils at 260° C. On oxidation it deposits stearopten, a camphor. This oil contains an alkaloid termed *cubebine* or piperine and a resin. When the oil is distilled it yields a hydrocarbon that forms a crystalline compound with HCl. When the oil is redistilled with water a camphor is formed that fuses at 65° C. The hydrocarbon of cubebs has the formula $C_{15}H_{24}$.

Oil of valerian consists of an oil of turpentine hydrocarbon and valerol. It is a liquid of a pale yellow colour, an acid reaction, and an aromatic taste. The hydrocarbon is identical with that of Borneo camphor. Valerol has the odour of hay, but when oxidized the unpleasant odour of valeric acid is emitted. It crystallizes at 0° C. in prisms that do not fuse till heated up to 20° C. It is dissolved in H_2SO_4, forming a red solution. The oil becomes glutinous at $-15°$ C., but does not entirely solidify at $-40°$ C. It has a specific gravity of ·91. It begins to boil at 200° C., and continues boiling up to 400° C. A yellowish oil passes over between 120° C. and 200° C., when the crude oil is fractionally distilled.

Oil of cumin consists of a hydrocarbon, $C_{10}H_{14}$, termed cymol, and $C_{10}H_{11}OH$, cumyl hydride. It is obtained by distilling the seeds of *Cuminum Cyminum* with water. The hydrocarbon and the hydride may be separated by the action of hydrosodic sulphide, when a crystalline compound is formed, that, when distilled after heating with KHo, yields the hydride. This hydride, when oxidized by nitric acid or the air, is converted into cuminic acid. It can be distilled without change if not exposed to the air. Potassic cuminate is formed when it is acted on by KHo.

Oil of lavender is a volatile yellowish oil having a bitter aromatic taste and a pleasant odour. It has a specific gravity of ·90. When kept it deposits laurel camphor. Concentrated acetic acid dissolves it. It consists of an oil of turpentine hydrocarbon and a camphor. The oil reddens litmus paper.

Oil of elemi consists of an oil of turpentine hydrocarbon, $C_{10}H_{16}$. It boils at 170° C., and compared with water its specific gravity is ·85. It forms liquid and solid compounds with HCl. When elemic resin is distilled with water it yields this oil, which is colourless and transparent. It has a faintish taste and a pleasant odour. It behaves like oil of turpentine with mineral acids, and heat has a similar effect on it.

Oil of lemons consists of an oil of turpentine hydrocarbon containing a little oxidized solid essence, $C_{10}H_{10}O_5$. It is obtained from the rinds of oranges or lemons. The hydrocarbon may be obtained by distilling the crude essence.

Oil of juniper consists of an oil of turpentine hydrocarbon, obtained by distilling the berries with water. It boils at 160°, and has a specific gravity of ·86. With water it forms $C_{10}H_{16} + OH_2$, a hydrate. It causes a left-handed rotation with a ray of polarized light. With HCl it forms a liquid compound. It is slightly soluble in alcohol.

Oil of bitter-fennel consists of two oils, the less volatile of which has the same composition as anise camphor, but unlike it does not solidify at 10° C. It boils at 224° C., and its specific gravity is somewhat less than water. The more volatile oil is of the same composition as oil of turpentine, and boils at 192° C. A substance having the formula $3C_{10}H_{16}8NO$ is obtained by the action of nitric oxide, which, when heated above 100° C., is decomposed.

Oil of savine consists of an oil of turpentine hydrocarbon, and is obtained by distilling the herb and berries of the savine with water. It is an almost colourless mobile oil. It boils at 160° C. On exposure to the air it becomes glutinous and yellow. It has a specific gravity of ·92. It is soluble in absolute alcohol. Nitric acid converts it into a reddish-yellow balsam.

Oil of rue is obtained by distilling garden rue with water. It consists of an oil of turpentine hydrocarbon, containing borneol and chiefly euodic aldehyde, $C_{10}H_{21}COH$, or a ketone with a little laurel aldehyde, $C_{11}H_{23}COH$. By acting on oil of rue with fuming HNO_3 capric acid and pelargonic acid are produced. It has a bitter taste and a disagreeable odour. It has a specific gravity of ·84. It freezes at – 2° C. and boils at 230° C.

Oil of thyme is procured by distilling the herb with water. It consists of a hydrocarbon thymene, $C_{10}H_{14}$, and thymol, $C_{10}H_{14}O$. The oil when fresh is colourless or yellow, but the ordinary oil is of a dark-brown colour. It has the odour of thyme and the taste of camphor. Thymene is the volatile portion. It boils at 165° C., and it has a specific gravity of ·88. Thymol is a solid, crystallizing in prisms. It solidifies at 44° C. and boils at 230° C. It forms about one-half of the oil, and has the odour of thyme. It is isomeric with cuminic alcohol and carvol. It is easily soluble in ether and alcohol, and sparingly soluble in water. It forms a compound with H_2SO_4. When treated with oxidizing agents $C_{12}H_{16}O_2$ (thymoil) is formed.

APPARATUS.

Fig. 3 is a representation of the apparatus used for the determination of the specific gravity of a vapour by the method of Dumas. G is a gas globe or balloon, the neck of which is drawn out to a point. Into this the liquid is introduced, and the balloon is plunged into the bath of oil B, heated considerably above the boiling-point of the liquid, and the balloon remains in the bath until the evolution of vapour ceases, when the point of the globe is melted by the blowpipe. For a further description of the process see the Determination of the Rational Formulæ of Organic Substances.

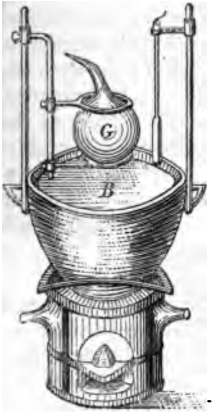


Fig. 3.

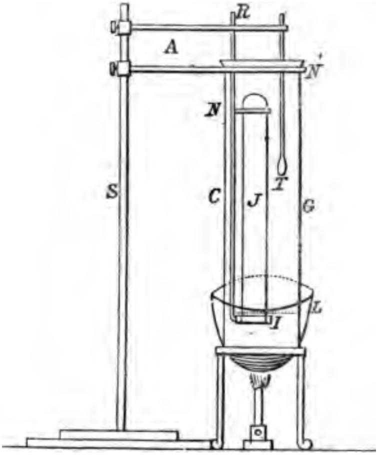


Fig. 4.

Fig. 4 is the representation of the apparatus employed for determining the specific gravity of a vapour by the method of Gay Lussac. C G is a cylindrical glass vessel test-tube, in form about 1 foot 6 inches long, and 5 inches in diameter. J is a gas-jar divided into half cubic centimetres, supported by an iron cap I attached to the rod R, and the upper end is kept in its place by the ring N. The cylinder C G is retained in position by the ring N′ attached to the retort stand S. The arm A supports the thermometer T and the rod R. There is mercury in the cylinder up to the dotted line, L and J is filled with mercury, and contains a glass bulb holding the fluid to be examined. The remainder of the cylinder is filled with water or oil to about 1 inch above the top of J. The cylinder may be supported on wire-gauze and heated by a Bunsen burner. The height of the column of water or oil in the cylinder must be reduced to mm. of mercury, which is added to the height of the barometer, and the height of the mercury in J, above the level of the mercury in C G, is deducted, giving the elastic force of the vapour. This gives us the volume which the known weight contained in the glass bulb inserted in J occupies at a given pressure and temperature. It then only remains to determine the weight of the same volume of air at the same pressure and temperature.

$$\text{Then density of vapour} = \frac{\text{weight of vapour}}{\text{weight of volume of air}}.$$

Fig. 5 represents the eudiometrical apparatus designed by Messrs. Frankland and Ward. In this apparatus G C is a glass cylinder 3 feet long by ⅓ foot in diameter, containing three smaller tubes, X, Y, and Z, which are connected at the bottom by F and H by means of the exit pipe E. The air or gas for analysis is introduced into the tube A, and the cocks *c′ c* are turned so as to allow its passage into X, which is assisted by elevating the mercury trough M, so that a few drops of mercury pass into X, driving the gas before it. The cock *c′* is then shut, and E turned so as to connect X and Z with E. A vacuum of 2 or 3 inches in length is formed in Z by allowing mercury to flow out until the mercury in X is just under one of the divisions. The cock E is then turned so as to allow mercury to pass from Y until the highest point in X corresponds with one of its highest divisions. There being ten divisions in X altogether, let this division be the seventh. Now determine the height of the mercury in Z, and deduct the height of the seventh division above zero in the tube Z, and thus obtain the true volume of the gas. The mercury trough is attached to the vertical pillar P P, on which it is capable of being moved up and down, together with its tube well W, by means of a rack and pinion *rp*. The apparatus is supported on a tripod T with levelling screws.

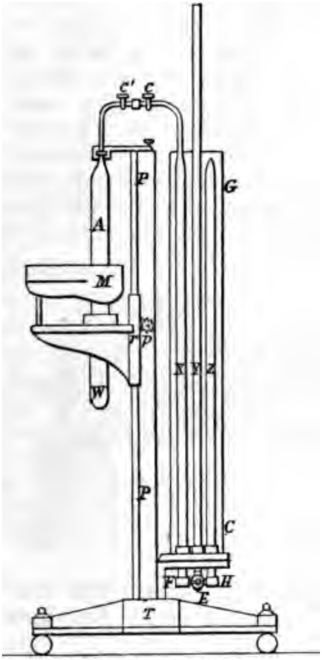


Fig. 5.

Suppose we have to analyze a mixture of oxygen, carbonic anhydride, and olefiant gas. By the introduction of a little of the concentrated solution of potash the CO_2 is speedily absorbed, and the remaining oxygen and olefiant gas is measured at the same pressure as were the three gases in the first instance, when the difference gives the volume of CO_2 that was present.

A strong solution of pyrogallic acid absorbs the oxygen, and remeasurement at the same pressure gives its amount. The gas remaining in this case will be olefiant; but suppose some other gas present besides, then the olefiant gas can be absorbed by introducing into A a coke bullet saturated with a strong H_2SO_4 solution of anhydrous sulphuric acid and the gas measured as before. The above is the method of direct determination of gases in gaseous mixtures. The indirect method has been explained in answer to one of the questions. Pass into X a certain volume of air, and half that volume of hydrogen, and determine the volume of the mixed gases. Now pass an electric spark through the mixed gases in X by means of the platinum wire, when an explosion and contraction in the volume takes place, and one-third of this contraction represents the volume of oxygen, and the remainder nitrogen.

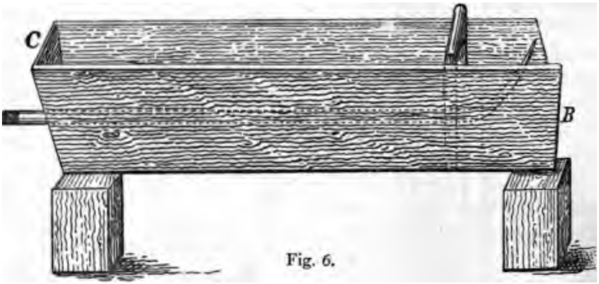
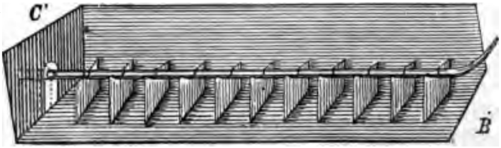


Fig. 6.

For those who cannot afford a gas-furnace like Hofmann's or Erlenmeyer's, of which a sketch has been already given (Fig. 1, p. 4), a combustion furnace made of stout sheet-iron of the form represented in Fig. 6, C B,

Fig. 7.



may be had for a few shillings. C′ B′ (Fig. 7) represents C B (Fig. 6) with the near side removed, so as to show the manner in which the combustion tube is supported. Fig. 8, E G C F, represents a cross section of Erlenmeyer's furnace (Fig. 1, p. 4).

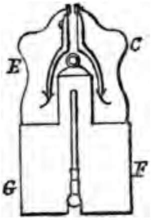


Fig. 8.

The combustion tube C T (Fig. 9) is made of the most infusible white Bohemian glass, and is sold of ½ or ¾ inch bore. In this tube the organic substance is ignited, and it is necessary that the glass should be very infusible so that it may not melt at the high temperature to which it is exposed in combustions.

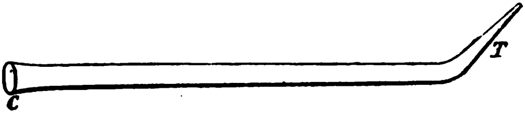


Fig. 9.

Volatile liquids are weighed in little bulbs of the form shown in B, Fig. 10. They are made by drawing out a piece of wide glass, W, before the blowpipe. The tube to contain the volatile liquid should be small enough to lie in the platinum boat. It is weighed, and heated, and put under the surface of the liquid, when some of the liquid will enter; then take the tube out and heat so as to drive out the air, and again place under the surface of the liquid to be analyzed, when it will be almost filled.

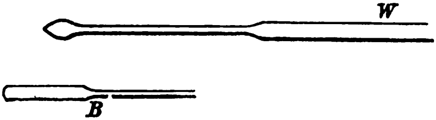


Fig. 10.

Take out of liquid, weigh, and transfer to the combustion tube.

The chloride of calcium tube for the absorption of the water produced may be of the form represented in C C T

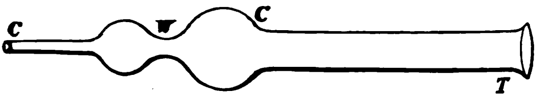


Fig. 11.

(Fig. 11) or C′ C′ T′ (Fig. 12), or some other convenient form. They are made of German glass, and may be 4, 5, or 6 inches long, and ⅜ or ½ inch in width. The fibres of some cotton wool are drawn by aspiration into the narrow neck W, then the larger bulb is filled with pieces of spongy chloride of calcium, and then small pieces until it is nearly filled. A plug of cotton wool is then inserted, and a cork through which a tube passes connecting this tube with the potash bulbs.

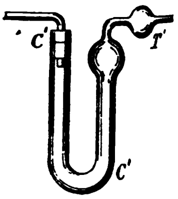


Fig. 12.

Fig. 13 represents the capillary portion of the tube A H B G twice bent at right angles at B and G. These tubes

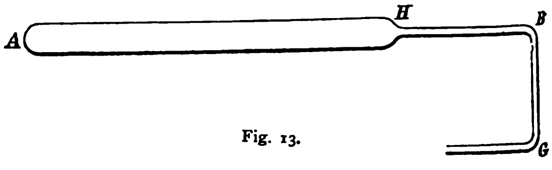


Fig. 13.

are used for the production of methyl and ethyl, and are made from hard Bohemian glass 1·3 mm. thick, 1 cm. in diameter, and 1 foot long, and one end closed before the blowpipe, and the open end drawn out straight to about the size shown in the figure and bent. The process for preparing methyl and ethyl has already been described.

The globular form of retort G R (Fig. 14) is used for liquids that rise at a very high temperature, but the form R (Fig. 15) is that generally used. The form F R (Fig. 16) is used for fractional distillation. It has a bent neck and a wide tubulure for insertion of the thermometer T.

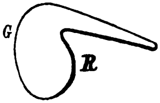


Fig. 14.

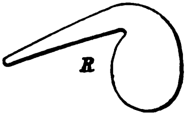


Fig. 15.

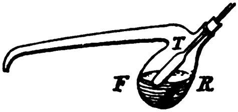


Fig. 16.

Fig. 17.

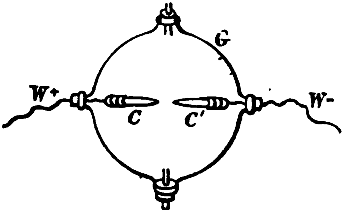


Fig. 18.

The glass tube in which substances are weighed before analysis is represented by Fig. 17.

The globe G (Fig. 18) with four necks is filled with hydrogen and the electric arc produced by the current passing between the carbon points C and C′ generates C_2H_2, acetylene, from which alcohol, C_2H_5Ho, can be prepared as already shown.

The vapour from the substance distilled in R passes nto the long glass tube G T (Fig. 19) that is surrounded, as seen in the figure, by a wide metal tube, through which runs a constant current of cold water supplied from the vessel V by means of the pipe P, and this water runs away by the pipe P′ to a drain or vessel V′. In this way the heated vapour is condensed, and passes as a liquid out of E into the vessel V″.

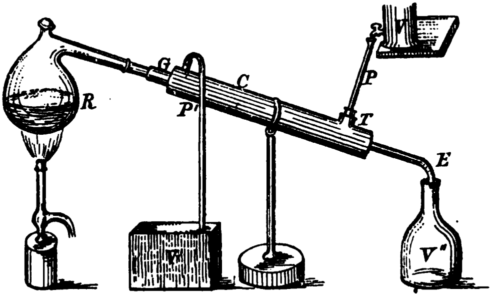


Fig. 19.

Geissler's potash apparatus, GPA (Fig. 20), is so constructed as to effectually absorb all the CO_2, and at the same time prevent any liquid running back to the combustion tube. It will be understood from the sketch in Fig. 20. The three small bulbs are filled to the extent shown in the figure by a solution of 3 parts of pure potash with 2 of water.

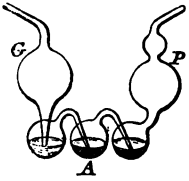


Fig. 20.

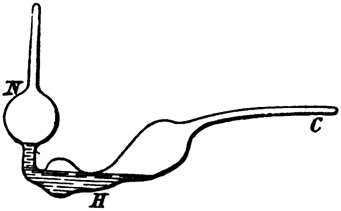


Fig. 21.

The apparatus NHC (Fig. 21) is filled to the extent shown, with HCl of about 1·1 specific gravity, in order to absorb the ammonia produced from the nitrogen contained in the organic body.

Fig. 22 shows a portion of the apparatus used for the determination of the nitrogen produced in the combustion of organic substances. The larger tube B is about 1½ foot long and 1 inch bore, and is graduated to show under 300 cubic centimetres. A is a U tube conducting the nitrogen into B for measurement.

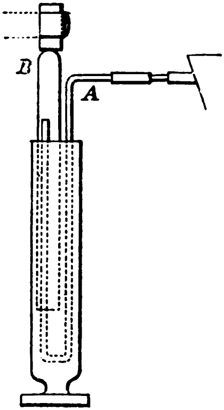


Fig. 22.

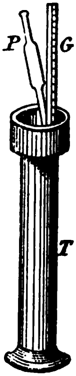


Fig. 23.

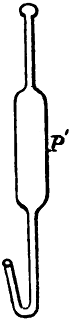


Fig. 24.

Fig. 23 represents a tall glass mercury trough T, in the broad mouth of which is placed a graduated tube G, and a pipette P, by which a potash solution is passed into the mixed nitrogen and carbonic anhydride for the purpose of absorbing the latter.

P' (Fig. 24) is a larger sketch of potash pipette.

EXERCISES.

1. What liquid on being evaporated leaves no residue, and has neither colour, taste, smell, nor action on test paper?

2. What effect is produced when an organic substance is heated?

3. What effect is produced when organic substances are heated with strong sulphuric acid? Give instances.

4. What organic substances leave a solid residue on evaporation?

5. What organic substances on evaporation leave an inflammable oily residue?

6. What organic substances on evaporation leave no residue?

7. What organic substances emit an ammonic odour on the application of heat, and turn red litmus paper blue?

8. What organic substances pass off in vapour and leave no black residue?

9. What organic substances leave a black residue on being heated?

10. What organic substances on being heated with the ordinary and then with the outer blowpipe flame leave a red or yellow residue?

11. What organic substances on being heated with the ordinary and then with the outer blowpipe flame leave an alkaline residue?

12. What organic substances on being heated do not evolve any odour nor blacken?

13. What organic substances evolve cyanogen on being heated?

14. What organic substance induces coughing on being heated?

15. What organic substances emit an odour like singed hair, and blacken when heated?

16. What organic substances emit the odour of sugar or burned wood, and blacken when heated?

17. What organic substances emit an odour like coal-tar when heated?

18. What organic substances produce an agreeable odour when heated?

19. What organic substances evolve ammonia, and blacken when heated?

20. What organic substances easily dissolve in water?

21. What organic substances dissolve in boiling water?

22. What organic substances dissolve in water yielding a solution that is acid but not astringent?

23. What organic substances dissolve in water yielding a solution that is both acid and astringent?

24. What organic substances produce an alkaline solution with water?

25. What organic substances produce a sweet solution with water?

26. What organic substances produce a bitter solution with water?

27. What organic substances produce with water a solution that is neither acid nor alkaline, and has no peculiar colour nor taste?

28. What organic substances yield a coloured solution with water?

29. What organic substances are insoluble in water?

30. What organic substances dissolve in alcohol?

31. What organic substances are insoluble in alcohol?

32. What organic substances are partly soluble in alcohol?

33. What organic substances are insoluble in water but soluble in hot alcohol?

34. What organic substances are soluble in ether?

35. What organic substances are insoluble in ether?

36. What organic substances are insoluble in water, sparingly soluble in alcohol, but soluble in boiling ether?

37. What organic substances are insoluble in boiling water, alcohol, and ether?

38. What organic substances dissolve in potassic hydrate?

39. What organic substances are insoluble in water to which potassic hydrate has been added, but dissolve on the addition of hydrochloric acid?

40. What organic substances are insoluble in water, potassic hydrate, or hydrochloric acid?

41. What organic substances taste acid?

42. What organic substances taste sweet?

43. What organic substances taste bitter?

44. What organic substances taste peculiar?

45. What organic substances are tasteless?

46. What organic liquids are acid to test paper?

47. What organic liquids are alkaline to test paper.

48. What organic liquids are neither acid nor alkaline to test paper?

49. What organic substances destroy the colour of a potassic iodide solution of iodine?

50. What organic substance gives a blue precipitate with a potassic iodide solution of iodine?

51. What organic substances give a yellow precipitate with a potassic iodide solution of iodine?

52. What substances give a brown precipitate with a potassic iodide solution of iodine?

53. Identify formic acid.

54. Identify malic acid.

55. Identify aniline and its salts.

56. Identify gallic and tannic acids.

57. Identify palmatine and spermaceti.

58. Identify carbolic acid and valerianic acid.

59. Identify morphine hydrochlorate, and quinine sulphate.

60. Identify benzoic acid, hippuric acid, uric acid, and succinic acid.

61. Identify acetic acid, hydrosulpho-cyanic acid, and meconic acid.

62. Identify glycerine, lactic acid, oleic acid, and oleine.

63. Identify citric acid, the cyanides, oxalic acid, and tartaric acid.

64. Identify the acetates, bitartrate of potash and tartar emetic.

65. Identify brucine, cinchonine, morphine, narcotine, nicotine, quinine, and strychnine.

66. Identify cholesterine, naphthaline, palmitic acid, rosin, stearic acid, and stearine.

67. Identify alcohol, aldehyde, acetone, butyric acid, and methylic alcohol.

68. Identify benzene, chloroform, ether, oil of bitter almonds, and nitrobenzole.

69. Identify albumen, pyrogallic acid, salicine, sugar (cane, grape, and milk), and urea.

70. Identify dextrine, gelatine, gum arabic, soap, starch, urea (nitrate and oxalate).

71. Identify caramel, caseine, chloral hydrate, indigo, paraffine, picric acid, wax and wood naphtha.

72. Identify the benzoates, caffeine, cinchonine sulphate, citrates, cyanides, morphine (acetate and meconate), nitroprussides, and the urates.

73. Separate organic acids into those precipitated by ferric chloride, those precipitated by calcic chloride, and those not precipitated by either.

74. Identify bitumen, paraffine, various oils, tar, resins, turpentine, &c.

75. Identify the various amines and amides.

76. Identify vinegar.

77. Identify the various kinds of soaps.

78. Identify kakodyl and its various derivatives.

79. Identify the various organometallic bodies.

80. Identify yeast.

81. Identify the phosphines, arsines, stibines, &c.

Make a qualitative analysis of the following mixtures:—

82. Tartrate of potash and soda, potassic sulphate, ammonic chloride and oxalate.

83. Coprolites.

84. Potassic ferrocyanide and iodide, Prussian blue, magnesic carbonate, and mercuric cyanide.

85. Benzoic acid, potassic oxalate, tartrate of potash and soda, sodic acetate and succinic acid.

86. Tartrate of potash and soda, sodic acetate, borax, zinc powder, and ammonic oxalate.

87. Plumbic and cupric acetates, arsenious anhydride, bismuthous oxide, and tartar emetic.

88. Sodic acetate and phosphate, succinic acid, calcic chloride, benzoic acid, and magnesic sulphate.

89. Ammonic sulphocyanate, manganous and zincic sulphates, oxalic acid and Prussian blue.

90. Guano.

91. Mixtures of organic acids and of their salts.

92. Mixtures of alkaloids, &c. &c.

93. Beef, or mutton, or pork, or blood, or milk, or flour, or oatmeal, or potatoes, or rice, or apples, or oranges, or tea, or coffee, or snuff, or opium, &c.

94. Manures.

95. Urine.

96. Bones.

97. Coal-tar.

98. Coal-gas.

99. Ink.

100. Coal.

101. Find the formula of an organic substance having the following percentage composition, viz.:—$C = 75$ and $H = 25$.

102. Find the formula of an organic substance having the following percentage composition, viz.:—Carbon = 92·31 and hydrogen = 7·69.

103. Find the formula of an organic substance having the following percentage composition, viz.:—Carbon = 46·15 and nitrogen = 53·85.

104. Find the formula of an organic compound havin

the following percentage composition, viz.:—C = 26·09, H = 4·35 and, O = 69·56.

105. Find the formula of an organic body composed of $C = 26\cdot\dot{6}$, $H = 2\cdot\dot{2}$ and $O = 71\cdot\dot{1}$ per cent.

106. Find the formula of a body composed of C = 68·85, H = 4·9, and O = 26·2 per cent.

107. Find the formula of a compound containing C = 48·6, H = 3·1, and O = 43·2 per cent.

108. Find the formula of a body containing $C = 54\cdot\dot{5}\dot{4}$, $H = 9\cdot\dot{0}\dot{9}$, and $O = 36\cdot\dot{3}\dot{6}$ per cent.

109. Find the formula of a substance containing C = 54·66, H = 8·74, and O = 36·6 per cent.

110. Find the formula of a substance containing C = 40, H = 6·7, and O = 53·3 per cent.

111. Find the formula of a body containing C = 48·66, H = 8·1, and O = 43·24 per cent.

112. Find the formula of a body containing C = 62·07, H = 10·34, and O = 27·59.

113. Find the formula of a body containing C = 72·49, H = 13·8, and O = 13·71.

114. Find the formula of a body containing C = 52·18, H = 13·04, and O = 34·78.

115. Find the formula of a body containing C = 23·76, H = 5·94, and Cl = 70·30 per cent.

116. Find the formula of a substance containing C = 20, $N = 46\cdot\dot{6}$, $H = 6\cdot\dot{6}$, and $O = 26\cdot\dot{6}$ per cent.

117. Find the formula of a substance containing C = 22·75, H = 2·84, O = 30·33, and chlorine = 44·08 per cent.

118. Find the formula of a substance containing C = 38·71, H = 16·13, and N = 45·16 per cent.

119. Find the formula of a substance containing C = 32·9, H = 2·83, N = 6·27, and I = 58.

120. Find the formula of a substance containing C = 6·75, H = 4·07, O = 21·96, and Ag = 47·23 per cent.

121. Find the formula of a substance containing C = 0, H = 6·66, O = 26·67, and N = 46·67.

122. How is the nitrogen in an organic body estimated y the ammonia process?

123. How is the nitrogen in an organic substance estimated quantitatively?

124. How are the elements bromine, chlorine, and iodine in an organic body estimated?

125. How are the elements sulphur, arsenic, and phosphorus in an organic body estimated?

126. The double salt formed by the hydrochlorate of morphine and platinic chloride yielded on ignition 20·15 per cent. of platinum. Calculate the molecular weight of morphine.

127. Find the molecular weight of acetic acid from the following data, viz.:—

	Grammes.
Argentic acetate taken, ...	5
Metallic silver after incineration, ...	3·2325

128. Find the vapour density of marsh-gas, ethyl hydride, &c., knowing that the density of air is 14·49 times that of hydrogen.

129. Find the rational formula when the vapour density is known as well as the elements that enter into the composition of the body.

130. Find the specific gravity of the vapours of methylic and ethylic alcohols.

131. What is the weight in grammes of a litre of ethylic iodide?

132. Analyze quantitatively a gaseous mixture of olefiant gas, marsh-gas, carbonic oxide, and nitrogen.

133. Find the formula of morphine from the following analysis of its hydrochlorate, viz.:—C = 54·47, O = 25·57, Cl = 9·32, H = 6·92, and N = 3·72.

134. Calculate the vapour density from the following data obtained by Hofmann's method, viz.:—

Observed height of barometer at 17°, ...	755 mm.
,, ,, mercury in tube at 185°, ...	561 mm.
Volume of vapour, ...	73·28 cc.
Temperature of vapour, ...	185° C.
Weight of vapour, ...	·0682 gr.
Coefficient of expansion of mercury, ...	·00018

135. An organic body containing the elements carbon, hydrogen, nitrogen, and iodine weighs ·4144 gr., the calcium tube weighed before 22·1345 grs., and 22·24 after combustion, and the potash bulbs weighed 75·2 grs., and after combustion 75·7, and ·497 gr. of the same body yielded ·5335 gr. of argentic iodide. Find the empirical formula.

136. The following data were obtained in determining the vapour density by Gay-Lussac's method, viz.:—

Weight of liquid used,......................	·167 gr.
Observed volume of vapour, ...	46·5 cc.
Temperature, ...	190°·5 C.
Height of barometer, ...	738·1 mm.
Height of inner column of mercury corrected for pressure of column of oil,	10·0 mm.

Find the molecular weight of the compound.

137. An organic body containing carbon, hydrogen, and oxygen weighs ·35 gr. The calcium tube weighs 21·367 grs. before and 21·525 after combustion, and the potash bulbs weigh 75 before and 75·881 grs. after combustion. Find the empirical formula.

138. In the eudiometrical analysis of a hydrocarbon gas the following numbers were obtained: Fill up the last column of corrected numbers and give the molecular formula and name of the gas:—

	Observed volume.	Temp.	Diff. of Hg. level.	Height of barometer.	Corrected vol. of dry gas at 0° C. and 1 metre pressure.
Gas used (moist),....	91·8	12·8° C.	623·1 mm.	752·7 mm.	
After admission of oxygen (moist),	535·1	12·9	160·6	751·7	
After combustion (moist),..........	498·8	12·8	194·0	751·1	
After absorption of CO_2 (dry), ...	454·3	13·0	237·2	741·5	

The tension of aqueous vapour at the above temperaure is—

At 12°·8,	11·0 mm. of mercury.
At 12°·9,	11·1 mm. ,,

139. Find the vapour density with reference to hydrogen from the following data:—

Weight of balloon and air,	24·8113 grs.
Temperature of oil-bath,	140° C.
Height of the barometer when sealing,	750 mm.
Weight of balloon filled with vapour,	24·8537 grs.
The temperature at weighing,	20° C.
Height of barometer at weighing,	740 mm.
Volume of balloon,	250 cc.

140. Prepare isopropylic alcohol from water, baryta, sodium, malt, rice, and yeast.

141. Find the percentage, composition, and formula of the substance from the following data:—

	Grammes.
Organic substance taken,	·3
Potash bulbs weighed before combustion,	75·375
,, ,, after ,,	75·838
Calcium tube weighed before combustion,	22·346
,, ,, after ,,	22·520

142. An organic body containing only carbon, hydrogen, and oxygen weighs ·3 gr., and the calcium tube weighs 22·6479 before and 23 grs. after combustion. The potash bulbs weigh 76 before and 76·5738 after combustion. Find the empirical formula of the substance.

143. An organic substance containing carbon, hydrogen, and oxygen weighs ·3 gr. The calcium tube weighs 22·326 before and 22·6779 grs. after combustion, and the potash bulbs weigh 75·365 before and 75·9388 grs. after combustion. The specific gravity of the substance referred to hydrogen is 23. Find the rational formula.

144. An organic body containing C, H, and O weighs ·3355 gr. The potash bulbs weigh 76·4893 before and 77·1608 grs. after combustion, and the calcium tube weighs 22·3641 before and 22·6386 grs. after combus-

tion. The vapour density referred to hydrogen is 44. Find the empirical and rational formula.

145. A carbinol weighs ·213 gr. The potash bulbs weigh 76 before and 76·566 grs. after combustion, and the calcium tube weighs 22·365 before and 22·63 after combustion. Find the formula.

146. An argentic salt of an organic monobasic acid weighs ·2065 gr. The potash bulbs weigh 76·736 before and 76·9425 after combustion, and the calcium tube weighs 22·376 before and 22·452 after combustion. The silver in this salt weighs ·09946. Find the formula and molecular weight of the acid.

PAPERS SET IN ORGANIC CHEMISTRY

AT THE

EXAMINATIONS OF THE SCIENCE AND ART DEPARTMENT, WITH ANSWERS, FROM 1868 TO 1878.

---

1. The formula of urea is CN_2H_4O, what is its percentage composition?

$C = 12$	$60 : 12 :: 100 :$ percentage of $C = 20$
$N_2 = 28$	$60 : 28 :: 100 :$ percentage of $N = 46{\cdot}\dot{6}$
$H_4 = 4$	$60 : 4 :: 100 :$ percentage of $H = 6{\cdot}\dot{6}$
$O = 16$	$60 : 16 :: 100 :$ percentage of $O = 26{\cdot}\dot{6}$
60	

2. Give the formula and percentage composition of marsh-gas.

CH_4 is the formula and

$C = 12$	$16 : 12 :: 100 :$ percentage of $C = 75$
$H = 4$	$16 : 4 :: 100 :$ percentage of $H = 25$
16	

3. When a powerful voltaic current passes between two pieces of gas carbon in an atmosphere of hydrogen, what chemical transformation is effected?

Acetylene is formed by the union of carbon and hydrogen.

How can you obtain acetic acid from alcohol?

By the oxidation of alcohol, by boiling it with chromic acid or with sulphuric acid and anhydrous potassic chromate, or by allowing it to drop slowly on platinum black, or by letting the alcohol trickle down a stack of loose shavings saturated with vinegar, or by mixing it with some vinegar and yeast, and keeping in a loosely closed vessel at a temperature above 20° C. The reaction is represented thus: $C_2H_5Ho + O_2 = CH_3COHo + OH_2$.

5. What is the composition of the organic acid contained in ants? Can you obtain this acid from any other source?

Formic acid, HCOHo. It may be obtained by the oxidation of methyl alcohol, tartaric acid, woody fibre, starch, &c.; by potassic hydrate or by a mixture of sulphuric acid and manganic oxide. For other methods see the preparation of formic acid.

6. Whence is methylic alcohol obtained, and how does differ in composition from ethylic alcohol?

See the alcohols for preparation. The first is obtained by acting on methyl chloride by potassic hydrate, thus: $CH_3Cl + KHo = CH_3Ho + KCl$; and the latter by acting on ethyl chloride by potassic hydrate, thus: $C_2H_5Cl + KHo = C_2H_5Ho + KCl$.

7. How can you detect hydrocyanic acid?

Distil with tartaric acid and add caustic potash to the distillate, then a mixture of a ferrous and a ferric salt and the HCl, when Prussian blue will be formed.

8. How is ether made, and what is its formula?

See preparation of.

9. What happens when hydrochloric acid gas is passed to absolute alcohol?

Ethylic chloride is formed, thus: $C_2H_5Ho + HCl = C_2H_5Cl + OH_2$.

10. What is the formula of chloroform, and how would ou obtain this body from ethylic alcohol?

$CHCl_3$ is its formula. See preparation.

11. How would you prepare olefiant gas?

See ethylene.

12. What is the composition of the liquid formed by the admixture of equal volumes of chlorine and olefiant gas?

$C_2H_4Cl_2$, ethylene dichloride or Dutch liquid.

13. When alcohol is boiled with bichromate of potash, what acid product is obtained?

Acetic acid, thus: $2K_2Cr_2O_7 + 8H_2SO_4 + 3C_2H_5Ho = 3CH_3COHo + 11H_2O + 2K_2SO_4 + 2Cr_2 3SO_4$. For $K_2Cr_2O_7$ requires H_2SO_4 for K_2 and $3H_2SO_4$ for Cr_2, thus: $K_2Cr_2O_7 + 4H_2SO_4 = 3O + 4H_2O + Cr_2 3SO_4 + K_2SO_4$, and the alcohol requires $2O$ for oxidation, thus: $C_2H_5Ho + 2O = CH_3COHo + OH_2$, now if we multiply the latter equation by 3, and the former by 2, we shall obtain 6 atoms of O on different sides of the equations, so that when we add the multiplied equations the first equation representing the reaction is obtained.

14. How would you estimate by analysis the percentage of carbon and hydrogen in an organic body?

See analysis.

15. What is the empirical formula of a substance possessing the following percentage composition:—carbon 40·00, hydrogen 6·66, and oxygen 53·34?

Dividing by the atomic weights of C, H, and O respectively, we obtain 3·33 for C, 6·66 for H, and 3·33 for O, and dividing by the smallest number 3·33, we get 1, 2, and 1 respectively for the C, H, and O, that is, we obtain the formula CH_2O. And the substance maybe $(CH_2O)_2 = C_2H_4O_2 = CH_3COHo$ acetic acid, or $(CH_2O)_3 = C_3H_6O_3 = CMeHHoCOHo$ lactic acid, or $(CH_2O)_6 = C_6H_{12}O_6$ grape-sugar.

16. Give the formula and percentage composition of common alcohol.

The formula is C_2H_5Ho and

$C_2 = 24$ and 46 : 24 : : 100 : percentage of carbon = 52·18.
$H_6 = 6$ 46 : 6 : : 100 : percentage of hydrogen = 13·04.
$O = 16$ 46 : 16 : : 100 : percentage of oxygen = 34·78.
—
46

17. Under what circumstances does marsh-gas occur in nature, and how can you prepare it artificially?

See the hydrides, and see accompanying figure (Fig. 25)

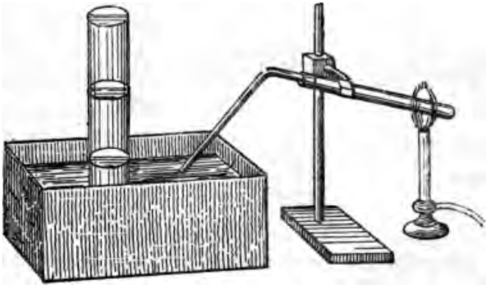
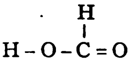
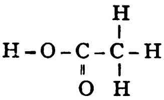
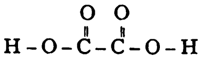
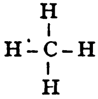
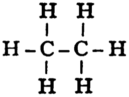
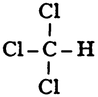
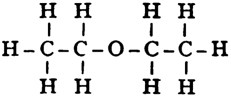


Fig. 25.

showing the arrangement for producing it by heating dry sodic acetate with soda lime and collecting the gas over water.

18. Give the symbolic and graphic formulæ of the following compounds:—formic acid, acetic acid, oxalic acid, marsh-gas, methyl, chloroform, and ether.

	Symbolic Formula.	Graphic Formula.
Formic acid………	$\begin{cases}H\\COHo\end{cases}$	 $H-O-\overset{\overset{H}{\vert}}{C}=O$
Acetic acid………	$\begin{cases}CH_3\\COHo\end{cases}$	 $H-O-\underset{\underset{O}{\Vert}}{C}-\overset{\overset{H}{\vert}}{\underset{\underset{H}{\vert}}{C}}-H$
Oxalic acid………	$\begin{cases}COHo\\COHo\end{cases}$	 $H-O-\overset{\overset{O}{\Vert}}{C}-\overset{\overset{O}{\Vert}}{C}-O-H$

	Symbolic Formula.	Graphic Formula.
Marsh-gas..........	CH_4	 $\begin{array}{c} H \\ \vert \\ H-C-H \\ \vert \\ H \end{array}$
Methyl..............	$\left\{\begin{array}{l} CH_3 \\ CH_3 \end{array}\right.$	 $\begin{array}{c} H\ \ H \\ \vert\ \ \vert \\ H-C-C-H \\ \vert\ \ \vert \\ H\ \ H \end{array}$
Chloroform.........	$CHCl_3$	 $\begin{array}{c} Cl \\ \vert \\ Cl-C-H \\ \vert \\ Cl \end{array}$
Ether............ ...	$\left\{\begin{array}{l} C_2H_5 \\ O \\ C_2H_5 \end{array}\right.$	 $\begin{array}{c} H\ \ H\quad\ H\ \ H \\ \vert\ \ \vert\quad\ \vert\ \ \vert \\ H-C-C-O-C-C-H \\ \vert\ \ \vert\quad\ \vert\ \ \vert \\ H\ \ H\quad\ H\ \ H \end{array}$

19. Describe the preparation and properties of the compound radical ethyl.

See the hydrides.

20. Some charcoal and caustic potash are given to you, and you are required to make prussic acid and oxalic acid; how will you proceed?

The charcoal and potash are heated in a tube to redness, and a current of nitrogen passed through, forming potassic cyanide, thus: $KHo + 2C + N = KCN + H + CO$, and by distilling with dilute sulphuric acid we obtain prussic acid, thus: $2KCN + H_2SO_4 = 2HCN + K_2SO_4$. We obtain potassic formiate by boiling the prussic or hydrocyanic acid with KHo, thus: $HCN + KHo + OH_2 = KCOHo + NH_3$, and when the formiate is heated it is converted into the oxalate, thus: $2KCOHo = (COKo)_2 + 2H$.

Now dissolve the oxalate in water and add calcic chloride, when calcic oxalate will be precipitated, and oxalic acid will crystallize out after dilute H_2SO_4 has been added to the precipitate.

21. Describe minutely how you would prepare ethylic iodide.

See the ethers.

22. What is the formula of phenylic alcohol or carbolic acid, whence is it obtained, and to what useful purpose has it been applied?

See the alcohols.

23. How are the monad positive radicals extracted from their iodides and from the acids of the acetic series?

See the hydrides.

24. What is the composition of acetic ether, and how would you prepare this substance?

See the ethers.

25. Give the formulæ and percentage composition of formic acid and oxalic acid.

The formula of formic acid is HCOHo or CH_2O_2.

$C = 12$ 46 : 12 : : 100 : percentage of carbon = 26·09
$H_2 = 2$ 46 : 2 : : 100 : percentage of hydrogen = 4·35
$O_2 = \underline{32}$ 46 : 32 : : 100 : percentage of oxygen = 69·56
46

The formula of oxalic acid is $(COHo)_2$ or $C_2H_2O_4$.

$C_2 = 24$ 90 : 24 : : 100 : percentage of carbon = $26·\dot{6}$
$H_2 = 2$ 90 : 2 : : 100 : percentage of hydrogen = $2·\dot{2}$
$O_4 = \underline{64}$ 90 : 64 : : 100 : percentage of oxygen = $71·\dot{1}$
90

26. Give two distinct and different processes for the preparation of ethylene, showing all the chemical changes by equations.

See the hydrides.

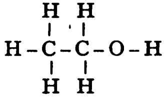
27. What is the empirical formula of a substance which yields the following results on analysis?

Carbon 20·00, hydrogen 6·66, oxygen 26·67, and nitrogen 46·67.

$$\left.\begin{array}{r} 20{\cdot}00 \div 12 = 1{\cdot}66 \div 1{\cdot}66 = 1C \\ 6{\cdot}66 \div 1 = 6{\cdot}66 \div 1{\cdot}66 = 4H \\ 26{\cdot}67 \div 16 = 1{\cdot}66 \div 1{\cdot}66 = 1O \\ 46{\cdot}67 \div 14 = 3{\cdot}33 \div 1{\cdot}66 = 2N \end{array}\right\} = CH_4ON_2 = \text{Urea} \left\{\begin{array}{l} NH_2 \\ CO \\ NH_2 \end{array}\right.$$

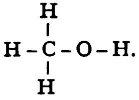
28. Give the graphic and symbolic formulæ of the following substances:—prussic acid, acetic acid, alcohol, methyl, and marsh-gas.

The formulæ for acetic acid, methyl, and marsh-gas are given previously.

	Graphic Formulæ.	Symbolic Formulæ.
Prussic acid......	$N \equiv C - H$	$\left\{\begin{array}{l} H \\ CN \end{array}\right.$
Alcohol	 $\begin{array}{ccccccc} & & H & & H & & \\ & & \vert & & \vert & & \\ H & - & C & - & C & - & O - H \\ & & \vert & & \vert & & \\ & & H & & H & & \end{array}$	C_2H_5Ho

29. What member of the alcohol family is found among the products of the destructive distillation of wood; how can you extract it in a state of purity from wood-naphtha, and what is its graphic formula?

See methyl alcohol.

The graphic formula is 

$$\begin{array}{ccccc} & & H & & \\ & & | & & \\ H & - & C & - & O - H. \\ & & | & & \\ & & H & & \end{array}$$

30. How can you detect the presence of nitrogen in an organic substance?

See the estimation of nitrogen.

31. You are required to make one ounce of lactic acid from milk; how will you do it?

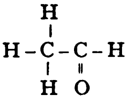
See the preparation of lactic acid.

32. Give the name and graphic formula of a member of each of the following families of organic compounds:—

alcohols, aldehydes, ethereal salts, ethers, and haloid ethers.

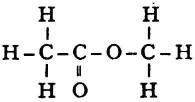
Alcohol and ether are given previously.

Acetic aldehyde,



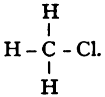
$H-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-\underset{\underset{O}{\|}}{C}-H$

Methyl acetate, an ethereal salt,



$H-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-\underset{\underset{O}{\|}}{C}-O-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-H$

Methyl chloride, a haloid ether,



$H-\overset{\overset{H}{|}}{\underset{\underset{H}{|}}{C}}-Cl.$

33. If a mixture of acetate of potash, caustic soda, and quicklime be heated to a temperature somewhat below redness, what gaseous product is obtained? Give its name and formula, and state where it is met with in nature.

See marsh-gas.

34. You have given you the following materials and are required to make acetic acid; state exactly what operations you will perform, and explain all chemical changes by equations:—ethylic iodide, sodic carbonate, quicklime, water, potassic chromate, and sulphuric acid.

Boil a solution of sodic carbonate, not too dilute, with the lime, and decant off the clear solution of caustic soda from the calcic carbonate which settles at the bottom.

The reaction is represented thus: $Na_2CO_3 + Ca H_2O_2 = 2Na Ho + Ca CO_3$. Concentrate the caustic soda solution and distil with the ethyl iodide in a retort giving a distillate containing alcohol, thus: $Na Ho + C_2H_5I = C_2H_5Ho + NaI$.

Acidulate the distillate with H_2SO_4, pour it on potassic chromate, and distil, when the distillate will contain acetic acid, thus: $3C_2H_5Ho + 10H_2SO_4 + 4K_2CrO_4 = 3CH_3COHo + 4K_2SO_4 + 2Cr_23SO_4 + 13H_2O$.

Now add sodic carbonate to the distillate until there is no further evolution of CO_2, evaporate to dryness and redistil with strong H_2SO_4, when acetic acid comes off. The reactions are as follows:

$$Na_2CO_3 + 2CH_3COHo = (CONaoCH_3)_2 + CO_2 + OH_2 \text{ and}$$
$$2(CH_3CONao) + H_2SO_4 = 2CH_3COHo + Na_2SO_4.$$

35. If an alkaline solution of potassic cyanide be boiled what decomposition takes place?

The formiate of potassium is formed and ammonia, thus: $KCN + 2H_2O = KCOHo + NH_3$.

36. If bitter almonds be macerated in warm water, what member of the aldehyde family is produced, and why is this aldehyde not formed when sweet are substituted for bitter almonds?

See benzoic aldehyde.

As amygdalin does not exist in sweet almonds the fermenting action cannot take place.

37. Describe the preparation of ethylic cyanide.

It is prepared by distilling together potassic ethyl sulphate and potassic cyanide, thus: $KEtSO_4 + KCN = EtCN + K_2SO_4$. It is decomposed by potassic hydrate, thus: $EtCN + KHo + OH_2 = EtCOKo + NH_3$. By this decomposition we can pass from the two to the three carbon compounds. EtCN boils at 97° C.

38. You have given to you some potash, charcoal, and sulphuric acid, and are required to prepare hydrocyanic acid; how will you do it?

See answer to No. 20.

39. You are required to analyze a mixture containing potassic formiate, calcic oxalate, and hydric potassic tartrate.

escribe how you will identify the organic acids present this mixture.

As calcic oxalate and hydric potassic tartrate are insoluble in water while the potassic formiate is soluble, add water and filter, and concentrate the filtrate, and test by boiling with H_2SO_4 or $AgNO_3$ as given under formic acid. To the residue add a solution of KHo, which dissolves the hydric potassic tartrate, leaving the oxalate. Warming the filtrate with H_2SO_4 produces a blackening from the separation of carbon and the characteristic odour.

The calcium oxalate evolves CO_2 on treatment with dilute H_2SO_4 and MnO_2, and when heated to redness it yields the carbonate.

40. How can oxatyl (oxalic acid) be converted into anogen and *vice versa?*

See cyanogen and oxatyl.

41. What reaction occurs when ethylic cyanide is boiled th a solution of caustic potash?

See answer to question No. 37.

42. The double salt formed by hydrochlorate of morine and platinic chloride, yields on ignition 20·14 per nt. of platinum. Calculate the molecular weight of orphine.

See the "Alkaloids" and also the "Methods for the Determination of the Rational Formulæ of Organic Substances."

The general formula for this double salt is $(C_mH_nO_pN_qHCl)_2PtCl_4$.

Then as 20·14 : 197·4 (the atomic weight of platinum) : : 100 : the molecular weight of the whole compound = 980·1. From 980·1 take 339·4, the atomic weight of $PtCl_4$, and divide the remainder, 640·7, by 2, giving 320·35, the molecular weight of $C_mH_nO_pN_qHCl$, and deducting from this 36·5 for HCl, we obtain 283·85, the required result.

43. Give the name and graphic formula of a member of each of the following families of organic compounds:—monad positive radicals, monad negative radicals, haloid ethers, and monobasic acids.

The graphic formulæ of methyl, oxalic acid, and formic acid are given in answer to question 18, methyl being a monad positive radical, oxalic acid a monad negative radical, and formic acid a monobasic acid. The graphic formula for methyl chloride, a haloid ether, is given in answer to question 32.

44. What takes place when methylic alcohol is added to a boiling solution of red potassic chromate acidified by sulphuric acid?

Formic acid is produced, thus: $3CH_3Ho + 2K_2Cr_2O_7 + 8H_2SO_4 = 3HCOHo + 2K_2SO_4 + 2Cr_23SO_4 + 11H_2O$.

45. How is phenylic alcohol manufactured, and what are its properties and uses?

See the alcohols.

46. You have given to you the following materials, and are required to make methylic hydride or marsh-gas. State concisely what operations you will perform and explain all chemical changes by equations:—alcohol, sodic carbonate, quicklime, water, potassic chromate, and sulphuric acid.

See answer to question 34 for the method of preparing sodium acetate, and turn to the hydrides for the method of preparing marsh-gas from sodic acetate and soda lime, or a mixture of lime and caustic soda.

47. An organic compound yielded on analysis the following results:—carbon 23·76, hydrogen 5·94, and chlorine 70·30. Give the empirical formula of the compound.

$$\left.\begin{array}{r}23{\cdot}76 \div 12 = 1{\cdot}98 \div 1{\cdot}98 = 1\ \mathrm{C}\\ 5{\cdot}94 \div 1 = 5{\cdot}94 \div 1{\cdot}98 = 3\ \mathrm{H}\\ 70{\cdot}30 + 35{\cdot}5 = 1{\cdot}98 \div 1{\cdot}98 = 1\ \mathrm{Cl}\end{array}\right\} CH_3Cl \text{ or methyl chloride.}$$

48. How would you experimentally determine the percentage of nitrogen in quinine?

See the estimation of nitrogen.

49. Describe a process for the preparation of the radical ethyl.

See the hydrides.

50. Define an organic acid, and state what acid is produced when ethylic alcohol is boiled with a mixture of potassic chromate and dilute sulphuric acid.

An organic acid consists of hydrogen, or an organic radical united with one or more atoms of the group COHo. Acetic acid is produced.

51. You are required to prepare pure cyanogen, and to fill a small glass cylinder with it. Describe minutely how you will do it; make a sketch of the apparatus, and show the nature of the chemical reaction by an equation.

See cyanogen. Fig. 26 shows an arrangement for producing it by heating mercuric cyanide and collecting over mercury.

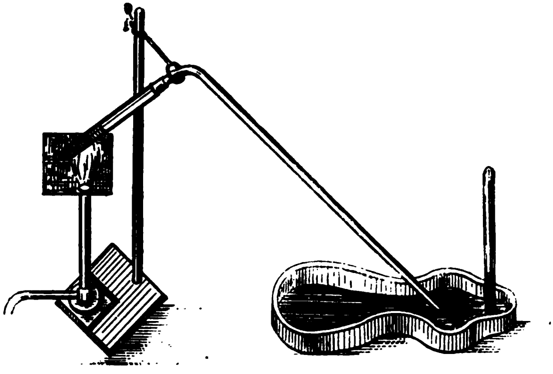
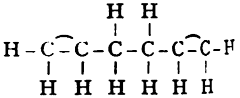


Fig. 26.

52. Give the name and graphic formula of a member

of each of the following families of organic compounds:—monad radicals of the vinyl series, hydrides of the monad positive radicals, the alcohols, and the aldehydes.

Allyl, a monad radical of the vinyl series,



$$H-\underset{H}{C}\frown\underset{H}{C}-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-\underset{H}{C}\frown\underset{H}{C}-H$$

The others have been given above.

53. Give the name and formula of the volatile compound which is formed when ethylic iodide is digested with sodic ethylate. Show the reaction by an equation.

$C_2H_5Nao + C_2H_5I = NaI + (C_2H_5)_2O$ (ether).

54. What organic compound is formed by the prolonged action at 100° C. of potassic hydrate upon carbonic oxide? Express the chemical change by an equation.

$KHo + CO = KCOHo$ (potassic formiate).

55. You have given to you the following materials, from which you are required to make lactic acid:—sugar, tartaric acid, decayed cheese, zincic carbonate, water, milk, chalk, sulphuric acid, and ferrous sulphide. Describe the necessary processes.

See the acids.

57. What is the empirical formula of an organic compound which yielded on analysis the following numbers? Carbon 22·75, hydrogen 2·84, oxygen 30·33, and chlorine 44·08.

$$\left.\begin{array}{l} 22{\cdot}75 \div 12 = 1{\cdot}896 \div 1{\cdot}242 = 1{\cdot}527 \times 4 = 6{\cdot}108 = 6 \text{ nearly C} \\ 2{\cdot}84 \div 1 = 2{\cdot}84 \div 1{\cdot}242 = 2{\cdot}287 \times 4 = 9{\cdot}148 = 9 \text{ nearly H} \\ 30{\cdot}33 \div 16 = 1{\cdot}896 \div 1{\cdot}242 = 1{\cdot}527 \times 4 = 6{\cdot}108 = 6 \text{ nearly O} \\ 44{\cdot}08 \div 35{\cdot}5 = 1{\cdot}242 \div 1{\cdot}242 = 1{\cdot}000 \times 4 = 4{\cdot}000 = 4 \qquad \text{Cl} \end{array}\right\} \begin{array}{l} C_6H_9 \\ O_6Cl_4 \end{array}$$

58. I mix together common alcohol and sulphuric acid, and distil the mixture with sodic butyrate. Give the name and formula of the chief volatile product, and illustrate the chemical changes by equations.

Butyric ether or ethyl butyrate, C_3H_7COEto.

$C_8H_7CONao + H_2SO_4 = NaHSO_4 + C_3H_7COHo$

and $C_3H_7COHo + C_2H_5Ho = C_3H_7CO(C_2H_5)o + OH_2$.

59. Describe how you would detect the presence of the following organic acids in a mixture of their salts:—citric acid, tartaric acid, and oxalic acid.

After making neutral with lime-water add calcic chloride, which will precipitate calcic tartrate and calcic oxalate, leaving the citric acid in the filtrate, which, when boiled, gives a precipitate of calcic citrate that is blackened and decomposed by boiling H_2SO_4. A solution of caustic potash dissolves the tartrate, leaving the oxalate, which yields CO_2 when treated with H_2SO_4 and MnO_2. By boiling the filtrate the tartrate is precipated and is blackened by H_2SO_4.

60. Describe the analytical process for the determination of carbon and hydrogen in an organic compound.

See analysis.

61. Give the formulæ and percentage composition of cyanogen and benzol.

The formula for cyanogen is $(CN)_2$.

$C_2=24$ 52 : 24 : : 100 : percentage of carbon = 46·15
$N_2=28$ 52 : 28 : : 100 : percentage of nitrogen = 53·85
52

The formula for benzol is C_6H_6.

$C_6=72$ 78 : 72 : : 100 : percentage of carbon = 92·31
$H_6=6$ 78 : 6 : : 100 : percentage of hydrogen = 7·69
78

62. What organic compound is produced when ethylic chloride is passed over quicklime heated to dull redness?

Ethylene, thus: $2C_2H_5Cl + CaO = CaCl_2 + 2C_2H_4 + OH_2$.

63. To a solution containing salts of the following acids, hydrocyanic, oxalic, tartaric, and citric, a solution of calcic chloride is added. A white precipitate insoluble in acetic

acid is formed. What is the composition of the insoluble precipitate?

Calcic oxalate $\left\{ \begin{array}{l} CO \\ CO \end{array} \right. Cao''$, calcic tartrate is soluble, and calcic citrate does not form in the cold.

64. How would you prepare ethylic iodide? Give a sketch of the apparatus.

See the haloid ethers.

65. To a cold solution containing a mixture of organic acids I add lime-water in excess: the solution remains clear, but becomes turbid on being heated to the boiling-point. What would you infer from this reaction?

That citric acid was present.

66. What organic compound is formed when carbonic anhydride is brought into contact with heated sodium?

Sodic oxalate, thus: $2Co_2 + Na_2 = (CONao)_2$.

67. What reaction takes place when chloroform is boiled with an alcoholic solution of potash?

It is transformed into potassic formiate, thus: $CHCl_3 + 4KHo = HCOKo + 3KCl + 2H_2O$.

68. What products of decomposition result when formic acid is boiled with mercuric oxide?

Mercury, carbonic anhydride, and water, thus: $HCOHo + HgO = Hg + CO_2 + OH_2$.

69. ·4144 gr. of an organic compound containing the elements C, H, I, and N, yielded on analysis ·5 gr. carbonic anhydride, and ·1055 gr. water. ·497 gr. of the same compound yielded ·5335 gr. of argentic iodide. Required the empirical formula of the compound.

$\cdot 5$ gr. of $CO_2 \times 3 \div 11 = \cdot 1\dot{3}\dot{6} = C$ and $\cdot 1055 \div 9 = \cdot 0117\dot{2} = H$. $\cdot 5335 \div 235 \times 127 = \cdot 31099 = I$; and

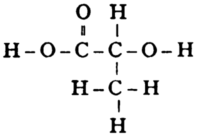
$$\begin{array}{l} C = \cdot 1\dot{3}\dot{6} \\ H = \cdot 01172;\ \text{then}\ \cdot 4144 - \cdot 3884 = \cdot 0260 = N. \\ I = \underline{\cdot 24038} \\ \qquad \cdot 3884 \end{array}$$

·4144 : ·136 : : 100 : percentage of carbon = 32·906 ÷ 12 = 2·742
·4144 : ·01172 : : 100 : percentage of hydrogen = 2·828 ÷ 1 = 2·828
·4144 : ·24038 : : 100 : percentage of iodine = 58·007 ÷ 127 = ·456
·4144 : ·026 : : 100 : percentage of nitrogen = 6·274 ÷ 14 = ·448

$$\left.\begin{array}{r} 2·742 \div ·448 = 6 \text{ nearly} = C \\ 2·828 \div ·448 = 6 \text{ nearly} = H \\ ·456 \div ·448 = 1 \text{ nearly} = I \\ ·448 \div ·448 = 1 \qquad\quad = N \end{array}\right\} = C_6H_6IN{=}N(C_6H_6)HI.$$

70. Draw the graphic formulæ of the following compounds:—acetic acid, oxatyl, ethylic alcohol, ethylic ether, acetic aldehyde, and lactic acid.

Lactic acid,



$$H-O-\overset{\overset{O}{\|}}{C}-\overset{\overset{H}{|}}{\underset{\underset{\underset{\underset{H}{|}}{H-C-H}}{|}}{C}}-O-H$$

The graphic formulæ of the others have been previously given.

71. Give the formulæ and percentage composition of acetic ether and benzoic acid.

Acetic ether $CH_3CO(C_2H_5)o$.

$C_4 = 48$ 88 : 48 : : 100 : percentage composition = 54·66 C
$H_8 = 8$ 88 : 8 : : 100 : percentage composition = 8·74 H
$O_2 = 32$ 88 : 32 : : 100 : percentage composition = 36·6 O
88

Benzoic acid C_6H_5COHo.

$C_7 = 84$ 122 : 84 : : 100 : percentage composition = 68·85 C
$H_6 = 6$ 122 : 6 : : 100 : percentage composition = 4·92 H
$O_2 = 32$ 122 : 32 : : 100 : percentage composition = 26·23 O
122

72. What is the name and formula of the organic compound which you obtain by boiling methylic alcohol with a solution of bleaching-powder?

See chloroform.

73. Define an alcohol. How can you obtain ethylic alcohol from ethylic bromide?

The alcohols are compounds of hydroxyl with the positive organic radicals.

By acting on it with caustic potash, thus: $C_2H_5Br + KHo = C_2H_5Ho + KBr$.

74. How would you separate alcohol from acetic acid?

Acetic acid freezes at 17° C. or under, while alcohol remains liquid at much lower temperatures.

75. If I pass a current of nitrogen gas over a mixture of charcoal and potash heated to whiteness, what chemical reactions take place?

Potassic cyanide is formed.

76. A substance gave the following numbers on combustion: 0·35 grm. gave 0·881 grm. carbonic anhydride, and 0·158 grm. water: it contained only the elements carbon, hydrogen, and oxygen. Find its empirical formula?

$$\cdot 881 \times 3 \div H = \cdot 2403 \text{ of C. and } \cdot 158 \div 9 = \cdot 0176 \text{ of H}$$

$$\cdot 35 - (\cdot 2403 + \cdot 0176) = \cdot 0921 \text{ of O}$$

$$\left.\begin{array}{l} \cdot 35 : \cdot 2403 :: 100 : 68\cdot 7 \div 12 = 5\cdot 725 \div 1\cdot 644 = 3\tfrac{1}{2} \times 2 = 7 \\ \cdot 35 : \cdot 0176 :: 100 : 5\cdot 0 \div 1 = 5 \quad \div 1\cdot 644 = 3 \quad \times 2 = 6 \\ \cdot 35 : \cdot 0921 :: 100 : 26\cdot 3 \div 16 = 1\cdot 644 \div 1\cdot 644 = 1 \quad \times 2 = 2 \end{array}\right\}$$

$$C_7H_6O_2 = \left\{\begin{array}{l} C_6H_5 \\ COHo \end{array}\right.$$

77. What chemical change is effected when an electric current is passed through a solution of potassic propionate?

It splits up into K and $C_3H_5O_2$, the latter immediately resolving itself into CO_2 and C_2H_5.

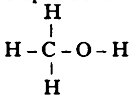
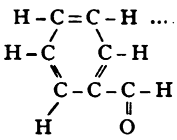
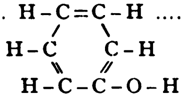
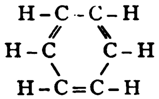
78. How would you prepare acetic acid from sugar?

By fermentation with yeast at a temperature about 22° C., thus: $C_6H_{12}O_6 = 2C_2H_5Ho + 2CO_2$; and by oxidation alcohol is converted into acetic acid, thus: $C_2H_5Ho + O = CH_3COH + OH_2$ and $CH_3COH + O = CH_3COHo$.

79. To a solution of potassic cyanide and potassic oxalate, a solution of argentic nitrate is added. What is the result, and what further change is effected on the addition of nitric acid?

White precipitates of argentic cyanide and oxalate are produced. Nitric acid dissolves the argentic oxalate but leaves the cyanide.

80. Give the graphic and symbolic formulæ of the following compounds: methylic alcohol, benzoic aldehyde, phenylic alcohol, benzol, and hydrocyanic acid.

	Graphic Formula.	Symbolic Formula.
Methylic alcohol, ...	 $H-\overset{H}{\underset{H}{C}}-O-H$	CH_3HO
Benzoic aldehyde, ...		$\left\{\begin{matrix}C_6H_5\\COH\end{matrix}\right.$
Phenylic alcohol, ...		C_6H_5HO
Benzol, ...		C_6H_5H

The formula for hydrocyanic or prussic acid has been given.

81. Give the percentage composition of lactic acid.

Lactic acid, $\begin{matrix}CMeHHO\\COHo\end{matrix}$, or $C_3H_6O_3$.

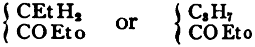
$3C=36$ 90 : 36 : : 100 : percentage composition $=40{\cdot}0=C$
$6H=\ 6$ 90 : 6 : : 100 : percentage composition $=\ 6{\cdot}\dot{6}=H$
$3O=48$ 90 : 48 : : 100 : percentage composition $=53{\cdot}\dot{3}=O$

90

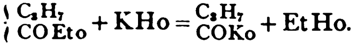
82. How are ethereal salts constituted? What happens when you boil ethylic butyrate with caustic potash?

They correspond to the metallic oxysalts of the acids, and are produced by the action of the alcohols on acids.

Ethylic butyrate,



$$\left\{\begin{array}{l}CEtH_2\\ COEto\end{array}\right. \text{ or } \left\{\begin{array}{l}C_3H_7\\ COEto\end{array}\right.$$



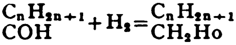
$$\left\{\begin{array}{l}C_3H_7\\ COEto\end{array}\right. + KHo = \begin{array}{l}C_3H_7\\ COKo\end{array} + EtHo.$$

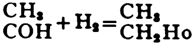
83. Express by an equation the change which occurs when common or ethylic alcohol is heated with excess of phosphoric anhydride.

$$3C_2H_5Ho + P_2O_5 = 2POHo_3 + 3C_2H_4.$$

84. How can an aldehyde be transformed into the corresponding alcohol?

By treatment with nascent hydrogen, thus:





$$\begin{array}{l}C_nH_{2n+1}\\ COH\end{array} + H_2 = \begin{array}{l}C_nH_{2n+1}\\ CH_2Ho\end{array} \text{ and } \begin{array}{l}CH_3\\ COH\end{array} + H_2 = \begin{array}{l}CH_3\\ CH_2Ho\end{array}$$ ethylic alcohol.

85. How can cyanogen be transformed into oxatyl and *vice versa?*

See oxatyl and cyanogen.

86. What is the action of sodium upon phenylic bromide?

Phenylic bromide, $2C_6H_5Br + Na_2 = 2NaBr + (C_6H_5)_2$ phenyl.

The radical phenyl $(C_6H_5)_2$ is produced.

87. How would you prepare ethylic ether? Give a sketch of the necessary apparatus, and express all chemical changes by equations.

See the ethers. The accompanying figure gives the necessary apparatus.

88. You have given to you oxalic acid and ammonia, and from these materials you are required to prepare cyanogen. How will you do it?

By adding ammonia to oxalic acid ammonium oxalate is formed, and when heated cyanogen is formed, thus: $\left\{\begin{matrix}COHo\\COHo\end{matrix}\right. + 2NH_3 = \left\{\begin{matrix}CONH_4o\\CONH_4o\end{matrix}\right. = \left\{\begin{matrix}CN\\CN\end{matrix}\right. + 4OH_2.$

89. Having at your disposal ethylene, hydrochloric acid, and potassic hydrate, how would you prepare ethylic alcohol?

$$\begin{matrix}CH_2\\CH_2\end{matrix} + HCl = \begin{matrix}CH_3\\CH_2Cl\end{matrix} \text{ and } \begin{matrix}CH_3\\CH_2Cl\end{matrix} + KHo = \begin{matrix}CH_3\\CH_2Ho\end{matrix} + KCl.$$

90. How would you prepare ethylic alcohol from ethylic iodide?

When treated with KHo, thus: $C_2H_5I + KHo = C_2H_5Ho + KI$.

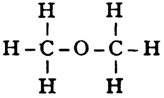
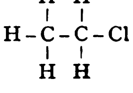
91. How would you individually recognize the constituents of a mixture containing oxalic acid, tartaric acid, and acetic acid?

The oxalic and tartaric acids give off CO and CO_2 when heated in a test-tube with strong sulphuric acid, and acetic acid gives off the vapour of acetic acid.

Tartaric acid when heated gives the odour of burned sugar.

$CaCl_2$ produces a white precipitate of calcic oxalate which is insoluble in acetic acid. Fe_2Cl_6 produces a dark-red colour with the acetic acid. $CaCl_2$ gives a white precipitate of calcic tartrate soluble in cold potassic or sodic hydrate, and the precipitate of calcic oxalate is not soluble.

92. Give the graphic and symbolic formulæ of the following compounds:—Methylic aldehyde, methylic ether, acetic acid, ethylic chloride, and the isolated radical methyl.

	Graphic Formula.	Symbolic Formula
Methylic ether,......	 $\begin{array}{ccccccccc} & & H & & & & H & & \\ & & \vert & & & & \vert & & \\ H & - & C & - & O & - & C & - & H \\ & & \vert & & & & \vert & & \\ & & H & & & & H & & \end{array}$	$\left\{\begin{matrix}CH_3\\O\\CH_3\end{matrix}\right.$
Ethylic chloride,....	 $\begin{array}{ccccccc} & & H & & H & & \\ & & \vert & & \vert & & \\ H & - & C & - & C & - & Cl \\ & & \vert & & \vert & & \\ & & H & & H & & \end{array}$	$\left\{\begin{matrix}CH_3\\CH_2Cl\end{matrix}\right.$

93. Define an organic acid, and illustrate your answer by examples.

An organic acid contains one or more semimolecules of oxatyl, combined with an organic radical, thus: acetic acid has CO Ho, a semimolecule of $(CO\,Ho)_2$, oxatyl, combined with CH_3, the monad positive radical methyl. Succinic acid contains two semimolecules of $(CO\,Ho)_2$ combined with C_2H_4, ethylene, thus: $\left\{\begin{matrix}CO\,Ho\\ C_2H_4\\ CO\,Ho\end{matrix}\right.$. Citric acid contains three semimolecules, thus: $\left\{\begin{matrix}CHHo\,CO\,Ho\\ CH_2CO\,Ho\\ CHCO\,Ho\end{matrix}\right.$. And pyromellitic acid, $C_6H_2(CO\,Ho)_4$, and mellitic, $C_6(CO\,Ho)_6$.

94. Give the formula and percentage composition of acetic aldehyde.

Acetic aldehyde, $\begin{matrix}CH_3\\ COH\end{matrix}$

$$\begin{aligned}2C&=24\\ 4H&=\ \ 4\\ O&=16\\ \hline &\ \ \ 44\end{aligned}$$

$44 : 24 :: 100 :$ percentage of carbon $=54\cdot\dot{5}\dot{4}$

$44 : \ \ 4 :: 100 :$ percentage of hydrogen $=\ \ 9\cdot\dot{0}\dot{9}$

$44 : 16 :: 100 :$ percentage of oxygen $=36\cdot\dot{3}\dot{6}$

95. The ultimate analysis of an organic compound containing carbon, hydrogen, and oxygen, gave the following results:—Carbon 52·17, hydrogen 13·04, and oxygen 34·79. What is the empirical formula of the compound?

$$\left.\begin{matrix}52\cdot17\div12=\ \ 4\cdot34\div2\cdot17=2=C_2\\ 13\cdot04\div\ \ 1=13\cdot04\div2\cdot17=6=H_6\\ 34\cdot79\div16=\ \ 2\cdot17\div2\cdot17=1=O\end{matrix}\right\}C_2H_6O.$$

96. Express by an equation the chemical change which occurs when ethylic acetate is boiled with solution of caustic potash.

$$\left\{\begin{matrix}CH_3\\ COEto\end{matrix}\right. + KHo = \left\{\begin{matrix}CH_3\\ COKo\end{matrix}\right. + Et\,Ho.$$

97. What is the constitution of the haloid ethers?

Give an equation showing the formation of one of these ethers.

The haloid ethers are formed by Cl, Br, or I, substituting the hydroxyl (HO) of the alcohols or the H of the hydrides.

$$C_nH_{2n+1}H + Cl_2 = HCl + C_nH_{2n+1}Cl$$
$$C_nH_{2n+1}HO + HCl = OH_2 + C_nH_{2n+1}Cl.$$

98. How could you prepare absolute alcohol?

See ethylic alcohol.

99. What chemical changes ensue when a mixture of ethylic iodide and zinc is heated to 150° C. in a sealed tube?

$2EtI + Zn = ZnI_2 + 2C_2H_5.$

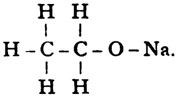
100. What is the alternative name of oxatyl, and how would you prepare this radical from sugar?

By heating in a porcelain dish a small quantity of sugar with twice its weight of strong nitric acid, and four times the weight of water. Boil until the evolution of the reddish yellow fumes ceases and put the liquid in a cool place, when oxalic acid will crystallize out.

101. I drop a piece of sodium in ethylic alcohol—what happens? Draw the graphic formula of the sodium compound which is produced.

Sodic ethylate, thus: $2\left\{\begin{matrix}CH_3\\CH_2\end{matrix}\right. Ho + Na_2 = 2\left\{\begin{matrix}CH_3\\CH_2\end{matrix}\right. Nao.$

Graphic formula,



$$\begin{array}{ccccccc} & & H & & H & & \\ & & | & & | & & \\ H & - & C & - & C & - & O - Na. \\ & & | & & | & & \\ & & H & & H & & \end{array}$$

102. Explain the action of an alcoholic solution of potash upon ethylenic dibromide.

When boiled with the alcoholic solution of potash, ethylenic bromide yields vinylic bromide, thus: $C_2H_4Br_2 + KHo = OH_2 + KBr + C_2H_3Br$ (vinylic bromide).

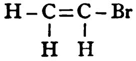
103. How would you qualitatively analyze a mixture containing hydrocyanic, tartaric, and citric acids?

Calcic hydrate gives a white precipitate of calcic tartrate, but gives no precipitate in the cold with citric acid, but when boiled there is a precipitate of calcic citrate. By inverting a small dish containing a drop or two of yellow ammonic sulphide over HCN, ammonic sulpho-cyanate, CNAmS, and AmHS are formed, which, on being acidified with HCl, give a characteristic blood-red coloration with Fe_2Cl_6.

104. Give some definition by which the compounds commonly called organic can be distinguished from those belonging to the mineral kingdom.

See distinction between organic and inorganic substances.

105. Give the graphic and symbolic formulæ of the following compounds:—acetic aldehyde, oxalic acid, marsh-gas, vinylic bromide, lactic acid, and methylic acetate.

	Graphic Formula.	Symbolic Formula.
Vinylic bromide,…………	 $\begin{matrix}H-C=C-Br\\ \ \ \ \ \,\vert\ \ \ \ \ \vert\\ \ \ \ \ H\ \ \ H\end{matrix}$	$\left\{\begin{matrix}CH_2\\CHBr.\end{matrix}\right.$

The others are already given.

106. Give the formula and percentage composition of methylic formate.

Methylic formate, $\left\{\begin{matrix}H\\COMeo.\end{matrix}\right.$

$2C = 24$ $60 : 24 :: 100 :$ percentage of $C = 40$
$4H = 4$ $60 : 4 :: 100 :$ percentage of $H = 6{\cdot}7$
$2O = 32$ $60 : 32 :: 100 :$ percentage of $O = 53{\cdot}3.$

60

107. What chemical change takes place when phosphoric chloride is put into ethylic alcohol?

$$4C_2H_5Ho + PCl_5 = 4C_2H_4 + 5HCl + POH_3O_3.$$

108. The ultimate analysis of an organic compound

consisting of carbon, hydrogen, and oxygen gave the following results:—·3 grm. yielded ·5738 grm. carbonic anhydride and ·3521 grm. water. Give the percentage composition and empirical formula of the compound.

$$\cdot5738 \times 3 \div 11 = \cdot1565 = C \text{ and } \cdot3521 \div 9 = \cdot0391 = H$$

$$\cdot3 - (\cdot1565 + \cdot0391) = \cdot1044 = O$$

$$\left.\begin{array}{l} 3000 : 1565 :: 100 : 52{\cdot}17 \div 12 = 4{\cdot}347 \div 2{\cdot}171 = 2 = C \\ 3000 : 391 :: 100 : 13{\cdot}03 \div 1 = 13{\cdot}03 \div 2{\cdot}171 = 6 = H \\ 3000 : 1044 :: 100 : 34{\cdot}80 \div 16 = 2{\cdot}171 \div 2{\cdot}171 = 1 = O \end{array}\right\} C_2H_6O.$$

109. Give the definition of an alcohol, and illustrate it by examples.

The alcohols are the compounds of the hydrocarbon radicals with hydroxyl.

	Monohydric.
Methyl series,	$C_nH_{2n+1}Ho$
Vinyl ,,	$C_nH_{2n-1}Ho$
Phenyl ,,	$C_nH_{2n-7}Ho$
	Dihydric.
Glycol series,	$C_nH_{2n}Ho_2$
Orcin ,,	$C_nH_{2n-8}Ho_2$
	Trihydric.
Glycerine series,	$C_nH_{2n-1}Ho_3$
Pyrogallic ,,	$C_nH_{2n-9}Ho_3$.

110. Describe minutely the methods you would employ and sketch the apparatus you would use for the purpose of preparing aqueous hydrocyanic acid, and give the equation.

See cyanogen.

111. How can marsh-gas be prepared from its elements?

See marsh-gas.

112. A salt of an organic acid gives a white precipitate with calcium chloride insoluble in acetic acid. What acid does this reaction indicate, and how would you prove this indication to be correct?

Oxalic acid. By adding concentrated H_2SO_4, and heating gently CO and CO_2 are given off without blackening.

113. Explain by an equation the decomposition which takes place when yeast is added to a solution of grape-sugar. Give a sketch of the apparatus by which you would demonstrate the formation of the two chief products.

See alcohol.

I have examined patent German and brewers' yeast microscopically, and find the sporules of a minute oval or circular shape present a similar appearance. This is the first stage of the existence of the yeast plant, which belongs to the tribe of fungi. After the lapse of some time the sporules change, circumstances being favourable, into the thallus (Fig. 27), or second stage of development. The sporules become elongated, divide, and form long-jointed threads. And in the third and last stage of its existence (Fig. 28) vertical threads shoot up from the thallus, become branched, bearing corpuscles

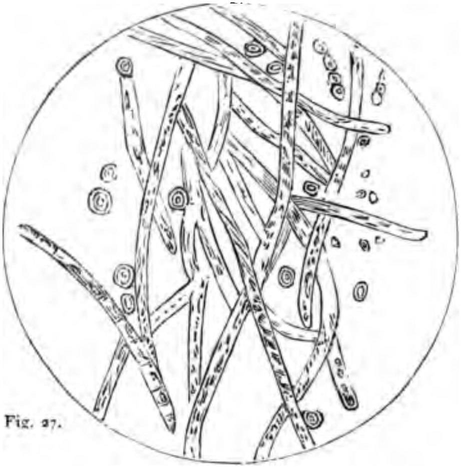


Fig. 27.

at their extremities about the size of the yeast sporules, but firmer in texture and of a darker colour.

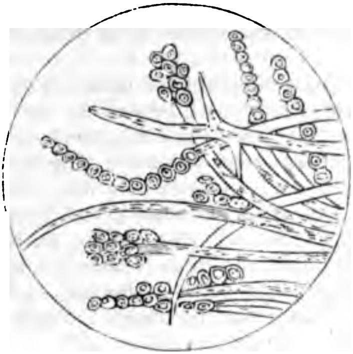


Fig. 28.

Patent yeast is a thin watery fluid of a pale yellowish colour, and when magnified about two hundred diam-

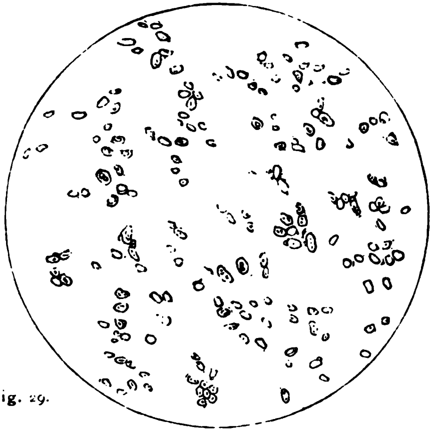


Fig. 29.

eters has the appearance presented in Fig. 29. It holds in suspension innumerable sporules of the yeast plants clustering together of an oval form. It is prepared from infusions of malt and hops, the latter being added to prevent the liquid from becoming rapidly sour. From its cheapness it is extensively used by bakers.

German yeast is one of the products of fermentation in the great continental breweries. It is identically the same as beer yeast, but has the moisture removed by filtration, and the carbonic anhydride dissipated. Thus it consists of sporules only with a little moisture, and is of a dingy light-brown colour, having the consistency of dough or paste. About six thousand tons are imported annually from Hamburg and Holland in bags containing half a hundredweight each. This large quantity is chiefly used by bakers. Much care is requisite in handling this yeast, since its vitality is destroye by pressure, cold, or heat.

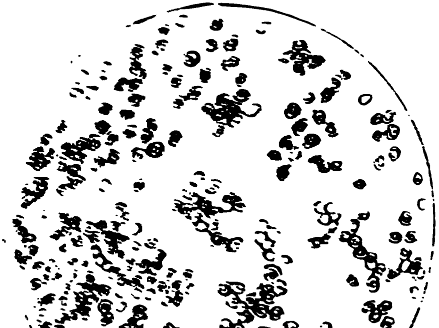


Fig. 30.

Brewers' yeast has a frothy appearance, and is of light-brown colour. When fresh it is inflated by th contained carbonic anhydride, and overflows vessels filled with it. But when the gas has effected its escape there is no further movement. When exposed to the air for some time it assumes a dirty fawn colour.

The sporules of yeast are spherical or ellipsoidal in form (Fig. 30). They are termed *Torula cerevisiæ*, and have a diameter of about $\frac{1}{3600}$th of an inch, or are about the same size as the red corpuscles of the human blood; but many are only half this size, while others are half as large again. When pressed the investing envelope is broken, and the contents of the cell flow out. The cell consists of a sac, an outside transparent spherical or ellipsoidal coating (*a*, Fig. 31), the contained protoplasm, a semi-fluid matter like ground glass (*b*), one or two vacuoles, small spaces clearer than the rest (*c*), and inside these one or two minute moving bodies (*e*).

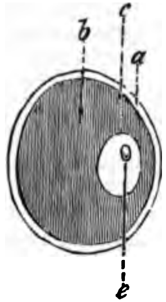


Fig. 31.

The most favourable temperature for the growth of the torula is about 20° C., and it should not rise above 60° C. or fall below 0° C. They grow by imbibing plasma through their cell walls, and by forming it into organizable matter by means of the protoplasm, and by the assimilation of this matter to form part of its own living substance. The cell-walls increase in size by an interstitial deposit derived from the protoplasm.

They increase in number by budding (Fig. 32) when the cells are in contact with an easily fermentable liquid, otherwise they increase by sporules (Fig. 33) formed inside the present cell, which eventually bursts, setting them free.

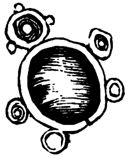


Fig. 32.

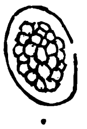


Fig. 33.

Acetic acid or dilute caustic potash dissolves out the protoplasm, leaving the cell-walls intact, and a solution of magenta or iodine stains the protoplasm, while the sac remains unaltered. The sac, or cell-wall, is composed of cellulose, which has a similar composition to woody fibre, starch, or gum, and contains water and mineral salts as well.

The protoplasm consists of protein, water, fat, and mineral salts. The protein consists of carbon, hydrogen, nitrogen, oxygen, and a little sulphur. The percentage composition is $C = 58{\cdot}2$, $H = 7{\cdot}2$, $N = 15{\cdot}1$, and $O = 19{\cdot}4$.

The mineral salts consist principally of salts of potassium, and form about one-sixth of the weight of the cell. Yeast produces, and is produced by, fermentation. Pasteur's fluid—containing in 10,000 parts 8396 parts of water, 1500 of cane-sugar, 100 of ammonic tartrate, 20 of potassic phosphate, 2 of calcic phosphate, and 2 of magnesic sulphate—is the best preparation or plasma for the production of the torula, or yeast plant. However, liquids containing grape-sugar when exposed to the air for a few hours become turbid, a sediment falls to the bottom, and a scum rises to the surface. The sediment yeast is produced at a low temperature, between 0° C. and 8° C. The surface yeast is produced at a higher temperature, best between 20° C. and 27° C. Fermentation is stopped at a temperature above 50° C., and below 0° C. it is suspended. Chlorine, bromine, iodine, strong mineral acids, alcohol, creosote, and a temperature of 100° C., destroy the action of yeast. The scum that is formed on the surface of the brewer's fermenting vat consists of yeast. The development of the yeast plant may be observed by putting a small quantity of yeast in a sugary solution on a plate of glass, and examining under the microscope, when the round or oval granules will at first appear; but after the lapse of a few hours these cells throw out buds, becoming independent torula, clustering round the parent in beautiful forms.

The cells do not increase in number in pure sugar, because pure sugar does not contain any nitrogenous matter, which is essential to their propagation. One part of yeast is required for the fermentation of 100 parts of sugar, and if the sugar is in excess the surplus remains unchanged. In the fermentation of beer the quantity of yeast is increased about seven times, owing to the nitrogenous matter present in the liquid.

Before cane-sugar is susceptible of fermentation it must assimilate water to convert it into grape-sugar, thus, $C_{12}H_{22}O_{11}$, cane-sugar, $+OH_2$, water, equals $2C_6H_{12}O_6$, grape-sugar, and from this circumstance more yeast is required to effect the fermentation of cane than grape sugar. Pasteur found that, out of 100 parts of sugar, alcohol and carbonic anhydride formed 95 parts, glycerine over 3, succinic acid less than 1 part, and 1 part disappeared in nourishing the yeast plant during growth.

The action by which yeast produces fermentation, forming alcohol and carbonic anhydride, is not, so far as I am aware, fully understood, but it would appear from various researches that fermentation consists in the conversion of matter containing nitrogen into organized torula. The sugar only ferments when in actual contact with the torula. Yeast is extensively used for making bread. It converts the sugar of the flour into alcohol and carbonic anhydride, which latter, by its tendency to escape from the dough, inflates it, forming air-spaces, rendering the dough light and porous. And it is probable that some of the starch is converted into sugar in the process of bread-making, thus rendering the bread sweet and palatable.

In making bread the baker takes a quantity of water, to which he adds salt, yeast, and afterwards the flour, when the whole is kneaded together until it assumes a ropy consistency called the sponge, which is placed in a warm place in the kneading-trough, when the yeast acts on the sugar of the flour, forming alcohol and carbonic anhydride, the latter inflating the sponge. When the fermentation has proceeded far enough the baker thoroughly incorporates more flour, salt, and water with the sponge, and allows this dough to remain for a few hours in a warm place, during which time it is inflated by the carbonic anhydride. It is afterwards weighed out into lumps, shaped into loaves, allowed to lie for a short time, placed in an oven, the temperature of which should not be less than 160° C., or more than 300° C. The heat dispels much of the water from the dough, and the crumb of the bread is enveloped in an atmosphere of steam, so that the temperature does not rise beyond 100° C. The heat stops the fermentation, for the action of yeast, as stated above, is destroyed by the temperature of boiling water. The heat also distends the air cavities still more, forms some dextrine from the starch, and partially boils the gluten and starch. The ends of the loaves become dry and hard, forming crust, and are partially converted into a substance similar to caramel, from the loss of two parts of water by the sugar of the flour by the heat. The alcohol formed by the yeast is expelled from the bread by the process of baking. Every 7 lbs. of flour yields 9 lbs. of bread, and, of course, when adulterated will give a larger yield. This is due in a great measure to an excess of water in the bread, of which there is about 45 per cent. There is scarcely any difference in the amount of water in new and stale bread. Stale can be converted into new bread by subjecting it to a temperature of 55° C., which is ordinarily effected by toasting. The difference between new and stale bread does not depend on the difference in the amount of contained water, but in molecular arrangement.

114. What acid is formed when a solution of sugar is mixed with milk, cheese, and calcic carbonate, and maintained at a temperature of about 35° C. for several days? Draw the graphic formula of the acid.

Lactic acid, $\left\{\begin{matrix}\text{CMe HHo}\\ \text{COHo}\end{matrix}\right.$.

Graphic formula given above.

115. Describe the preparation of ethylic acetate or acetic ether, and give a brief sketch of the apparatus you would use.

See answer to No. 24.

116. What is meant by a compound radical? Illustrate your definition by a comparison of the salts of potassium with those of ethyl.

A compound radical is a group of elements that acts in the same manner as an element. For remainder of answer see theory of compound organic radicals.

117. Give the formula and percentage composition of acetic ether.

Acetic ether, $\left\{\begin{matrix}\text{CH}_3\\ \text{COEto}\end{matrix}\right.$.

$C_4=48$ 88 : 48 : : 100 : percentage of $C=54\cdot\dot{5}\dot{4}$

$H_8=\ 8$ 88 : 8 : : 100 : percentage of $H=\ 9\cdot\dot{0}\dot{9}$

$O_2=32$ 88 : 32 : : 100 : percentage of $O=36\cdot\dot{3}\dot{6}$

$\overline{88}$

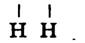
118. An organic compound gave the following numbers on analysis. What is its empirical formula? Carbon 26·66, oxygen 71·12, and hydrogen 2·22.

$$\left.\begin{array}{l}26\cdot66\div12=2\cdot22\div2\cdot22=1=C\\ 71\cdot12\div16=4\cdot44\div2\cdot22=2=O\\ 2\cdot22\div\ 1=2\cdot22\div2\cdot22=1=H\end{array}\right\}\text{COHO.}$$

119. Draw the graphic formulæ of the following compounds—vinylic chloride, ethylene, formic acid, phenylic alcohol, acetic acid, and ethylic butyrate.

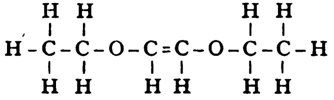
Graphic Formula.

Ethylene,



$$\begin{array}{ccccccc}H&-&C&=&C&-&H\\ &&|&&|&&\\ &&H&&H&&\end{array}$$

Ethylic butyrate,



$$\begin{array}{ccccccccccccccccccc}&&H&&H&&&&&&&&&&H&&H&&\\ &&|&&|&&&&&&&&&&|&&|&&\\ H&-&C&-&C&-&O&-&C&=&C&-&O&-&C&-&C&-&H\\ &&|&&|&&&&|&&|&&&&|&&|&&\\ &&H&&H&&&&H&&H&&&&H&&H&&\end{array}$$

The others are given above.

120. How do you define an aldehyde? Illustrate your definition by examples.

The aldehydes are bodies containing the group CoH combined with organic radicals. They are formed by the abstraction of hydrogen from the alcohols.

See the aldehydes for further information.

121. Mention the different kinds of ethereal salts, giving the name and formula of an example of each.

See the ethereal salts.

122. How can acetic acid be prepared—(1), in aqueous solution; (2), in the anhydrous state? Give equations and a sketch of apparatus needed.

See answer to previous question and acetic acid.

123. What happens when a mixture of common alcohol and sulphuric acid is heated? Give equation.

Ether is produced, thus: $EtHo + H_2SO_4 = OH_2 + HEtSO_4$, and $HEtSO_4 + EtHo = H_2SO_4 + Et_2O$ (ether).

124. How would you demonstrate that cyanogen gas contains carbon and nitrogen? Sketch the apparatus.

See cyanogen.

125. Explain how ethyl ether is made by the continuous process, giving equations showing the changes which occur, and a drawing of the apparatus.

See answer above.

126. Describe the preparation of methyl (ethane) by two different processes. Give equations.

See the hydrides.

127. What chemical changes occur when potassic cyanide is boiled with solution of caustic potash?

$HCN + KHo = OH_2 + KCN.$

128. Calculate the empirical formula of an organic

compound yielding the following percentage composition: —carbon 48·66, hydrogen 8·10, and oxygen 43·24.

$$\left.\begin{array}{l} 48{\cdot}66 \div 12 = 4{\cdot}055 \div 2{\cdot}7 = 1{\cdot}5 \times 2 = 3 \\ 8{\cdot}10 \div 1 = 8{\cdot}10 \div 2{\cdot}7 = 3 \times 2 = 6 \\ 43{\cdot}24 \div 16 = 2{\cdot}70 \div 2{\cdot}7 = 1 \times 2 = 2 \end{array}\right\} C_3H_6O_2.$$

129. How many litres of oxygen will be required in order to burn completely a mixture of one litre of marsh-gas and one litre of ethylene?

$$\begin{array}{l} CH_4 + 4O = CO_2 + 2OH_2 \therefore 2 \text{ litres required} \\ C_2H_4 + 6O = 2CO_2 + 2OH_2 \therefore 3 \text{ litres required,} \end{array}$$

and 5 litres will be required for the mixture.

130. What is the composition of phenol or carbolic acid, and in what relation does it stand to benzol?

See benzol and carbolic acid.

131. Draw the graphic formulæ of ethylene, methyl alcohol, benzoic acid, ethyl ether, and methylic cyanide.

See formulæ above.

132. What compound radicals do you recognize in the following compounds: formic acid, methyl alcohol, hydrocyanic acid, acetic acid, acetic ether?

In formic acid, $HCOHo$, there is the negative radical $COHo$; in methyl alcohol, CH_3Ho, there is the radical methyl CH_3; in hydrocyanic acid, HCN, there is the negative radical CN; in acetic acid, CH_3COHo, there is the positive radical CH_3 and the negative $COHo$; and in acetic ether there are the radicals CH_3 and C_2H_5.

133. Give the formula and percentage composition of butyric ether.

Butyric ether, $\left\{\begin{matrix} C_3H_7 \\ COC_2H_5o. \end{matrix}\right.$

$$\begin{array}{ll} C_6 = 72 & 116 : 72 :: 100 : \text{percentage of } C = 62{\cdot}07 \\ H_{12} = 12 & 116 : 12 :: 100 : \text{percentage of } H = 10{\cdot}34 \\ O_2 = 32 & 116 : 32 :: 100 : \text{percentage of } O = 27{\cdot}59 \\ \overline{116} & \end{array}$$

134. How would you perform the analysis of an organic body containing carbon, hydrogen, nitrogen, oxygen, and sulphur?

See analysis.

135. The analysis of an organic compound containing carbon, hydrogen, and oxygen gave the following experimental data:—substance burned, ·3 grm., CO_2 produced ·5738 grm., and OH_2 ·3519 grm.

The vapour density of the substance referred to the specific gravity of hydrogen as unity was found to be 23. What is the percentage composition and the rational formula of the compound?

$${\cdot}5738 \times 3 \div 11 = {\cdot}1565 = C \text{ and } {\cdot}3519 \div 9 = {\cdot}0391 = H \text{ and}$$

$${\cdot}3 - ({\cdot}1565 + {\cdot}0391) = {\cdot}1044 = O; \text{ then}$$

$$\left.\begin{array}{l} {\cdot}3 : {\cdot}1565 :: 100 : 52{\cdot}166 \div 12 = 4{\cdot}3466 \div 2{\cdot}175 = 2 = C \\ {\cdot}3 : {\cdot}0391 :: 100 : 13{\cdot}033 \div \ \ 1 = 13{\cdot}033 \ \div 2{\cdot}175 = 6 = H \\ {\cdot}3 : {\cdot}1044 :: 100 : 34{\cdot}8 \ \ \div 16 = \ 2{\cdot}175 \ \div 2{\cdot}175 = 1 = O \end{array}\right\} C_2H_6O.$$

$$\left.\begin{array}{l} C_2 = 24 \\ H_6 = \ 6 \\ O = 16 \end{array}\right\} = 46 \div 2 = 23,$$ therefore the percentage composition is C 52·166, H 13·033, and O 34·8, and the rational formula is C_2H_5Ho.

The next question, referring to graphic formulæ, has been answered elsewhere, as well as the following, referring to coal-gas.

136. Whence is benzol obtained, what is its formula, and how can it be converted into aniline and then into magenta?

See benzol, aniline, and magenta.

137. How would you prepare valeric acid and oxalic ether?

By oxidizing amylic alcohol by H_2SO_4, and potassic dichromate:—$C_5H_{11}Ho + O_2 = OH_2 + C_4H_9COHo$, valeric acid.

Oxalic ether is prepared by distilling a mixture of 4 parts of hydric-potassic oxalate, 4 of alcohol (sp. gr.

·83), and 5 of H_2SO_4: wash the distillate with water, and rectify from PbO. The formula is $(COEto)_2$.

138. What is the specific gravity of the vapour of amylic alcohol, the density of hydrogen being taken as unity?

Amylic alcohol, $C_5H_{11}Ho$.

$$\begin{aligned} C_5 &= 60 \\ H_{12} &= 12 \\ O &= 16 \\ \hline & 88 \div 2 = 44. \end{aligned}$$

139. Describe the reactions by which acetone is obtained from acetic acid.

See the ketones.

The next question, relating to the law of the basicity of acids, has been given.

140. What relation exists between cyanogen and oxalic acid, and how can each be transformed into the other?

If $(CN)_2$ be dissolved in water it is transformed into ammonic oxalate, thus, $\left\{\begin{matrix}CN\\CN\end{matrix}\right. + 4OH_2 = \left\{\begin{matrix}CONH_4o\\CONH_4o.\end{matrix}\right.$

In the presence of KHo cyanogen evolves NH_3, and produces $\left\{\begin{matrix}COKo\\COKo\end{matrix}\right.$, and from either of these salts $\left\{\begin{matrix}COHo\\COHo\end{matrix}\right.$ may be obtained by the action of H_2SO_4.

Conversely oxatyl may be converted into $(CN)_2$ by transforming it in ammonic oxalate, and submitting this salt to the action of heat: thus, $\left\{\begin{matrix}CONH_4o\\CONH_4o\end{matrix}\right. = 4OH_2 + \left\{\begin{matrix}CN\\CN.\end{matrix}\right.$

141. How can you obtain formic acid from saw-dust?

By oxidizing the saw-dust by a mixture of H_2SO_4 and MnO_2, or by KHo or CrO_2Ho_2.

142. If you had given to you some sugar, yeast, water, sodic carbonate, and sulphuric acid, and were required to prepare ethylic acetate (acetic ether) how would you do it?

See acetic ether.

143. If the electric light be produced by the voltaic ignition of carbon in an atmosphere of hydrogen, what chemical change, if any, takes place?

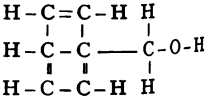
Acetylene, C_2H_2, is produced.

144. Give the graphic formula of a member of each of the following series of organic bodies:—organic radicals; hydrides of organic radicals; monacid, diacid, and triacid alcohols; monobasic acids of the acrylic, lactic, and pyruvic series; dibasic acids of the succinic and tartaric series.

Organic radical methyl given above.

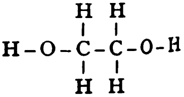
Hydride of organic radical, methyl hydride, given above.

Monacid alcohol, benzylic alcohol, $\left.\begin{matrix}C_6H_5\\CH_2Ho\end{matrix}\right\}$



General formula, $\begin{matrix}C_nH_{2n-7}\\CH_2Ho.\end{matrix}$

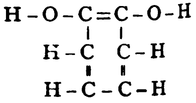
Diacid alcohol glycol, $\left\{\begin{matrix}CH_2Ho\\CH_2Ho\end{matrix}\right.$



$$H-O-\underset{H}{\overset{H}{\overset{|}{\underset{|}{C}}}}-\underset{H}{\overset{H}{\overset{|}{\underset{|}{C}}}}-O-H$$

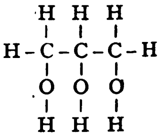
General formula, $C_nH_{2n}Ho_2$.

Hydroquinone, $C_6H_4Ho_2$,



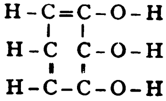
General formula, $C_nH_{2n-8}Ho_2$.

Triacid alcohol glycerine, $\left\{\begin{matrix}CH_2HO\\CHHO\\CH_2HO\end{matrix}\right.$



General formula, $C_nH_{2n-1}Ho_3$.

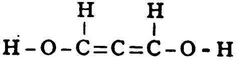
Pyrogallin, $C_6H_3Ho_3$,



$$\begin{array}{ccccccccc} H&-&C&=&C&-&O&-&H \\ &&|&&|&&&& \\ H&-&C&&C&-&O&-&H \\ &&\|&&\|&&&& \\ H&-&C&-&C&-&O&-&H \end{array}$$

General formula, $C_nH_{2n-9}Ho_3$.

Acrylic series, acrylic acid, $\begin{array}{l}CMe''H\\COHo\end{array}$, or $\left\{\begin{array}{l}C(CH_2)''H\\COHo\end{array}\right.$

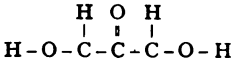


$$\begin{array}{ccccccccccccc} &&&&H&&&&H&&&& \\ &&&&|&&&&|&&&& \\ H&-&O&-&C&=&C&=&C&-&O&-&H \end{array}$$

General formula, $\left\{\begin{array}{l}C(C_nH_{2n})''(C_mH_{2m+1})\\COHo.\end{array}\right.$

Lactic acid given above.

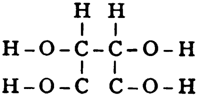
Pyruvic series, pyruvic acid, $\left\{\begin{array}{l}COMe\\COHo\end{array}\right.$



$$\begin{array}{ccccccccccccc} &&&&H&&O&&H&&&& \\ &&&&|&&\|&&|&&&& \\ H&-&O&-&C&-&C&-&C&-&O&-&H \end{array}$$

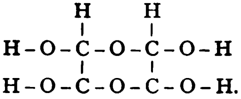
General formula, $\left\{\begin{array}{l}CO(C_nH_{2n+1})\\COHo.\end{array}\right.$

Succinic acid, $\left\{\begin{array}{l}COHo\\CH_2\\CH_2\\COHo\end{array}\right.$



$$\begin{array}{ccccccccccc} &&&&H&&H&&&& \\ &&&&|&&|&&&& \\ H&-&O&-&C&-&C&-&O&-&H \\ &&&&|&&|&&&& \\ H&-&O&-&C&&C&-&O&-&H \end{array}$$

Tartaric acid, $\left\{\begin{array}{l}COHo\\CHHo\\CHHo\\COHo\end{array}\right.$



$$\begin{array}{ccccccccccccc} &&&&H&&&&H&&&& \\ &&&&|&&&&|&&&& \\ H&-&O&-&C&-&O&-&C&-&O&-&H \\ &&&&|&&&&|&&&& \\ H&-&O&-&C&-&O&-&C&-&O&-&H. \end{array}$$

145. How would you prepare glycol?

By treating ethylenic dibromide, $\left\{\begin{array}{l}CH_2Br\\CH_2Br\end{array}\right.$, with argentic acetate, $2CMeOAgO = \begin{array}{l}CH_2-O-CMeO\\CH_2-O-CMeO\end{array} + 2AgBr$, and the ethylenic diacetate is now acted upon by KHo, and yields potassic acetate and glycol, thus: $\left\{\begin{array}{l}CH_2-O-CMeO\\CH_2-O-CMeO\end{array}\right. + 2KHo = \left\{\begin{array}{l}CH_2Ho\\CH_2Ho\end{array}\right. + 2CMeOKo.$

146. Describe how you would obtain lactic acid and ohol from their elements without the aid of animal or getable life.

Nascent hydrogen acting on acetylene, C_2H_2, which is produced by the electric current passing between two carbon points in an atmosphere of hydrogen, produces C_2H_4 (ethylene), then add HCl and we obtain $\begin{matrix}CH_3\\CH_2Cl\end{matrix}$; and adding $KHo = KCl + \left\{\begin{matrix}CH_3\\CH_2Ho\end{matrix}\right.$, and $H_2SO_4 = HEtSO_4 + OH_2$, and $HEtSO_4 + KCN = \left\{\begin{matrix}CMeH_2\\CN\end{matrix}\right. + HKSO_4$, and $\left\{\begin{matrix}C_2H_5\\CN\end{matrix}\right. + KHo + OH_2 = NH_3 + \left\{\begin{matrix}C_2H_5\\COHo\end{matrix}\right.$. Lactic acid is formed by the oxidation of propylic glycol, thus: $\left\{\begin{matrix}CMeHHo\\CH_2Ho\end{matrix}\right. + O_2 = OH_2 + \left\{\begin{matrix}CMeHHo\\COHo\end{matrix}\right.$; and propyl glycol is formed from propylene, C_3H_6, by preparing the dibromide and decomposing it with potassic acetate, obtaining the glycol monacetate, which, distilled with KHo, gives propylic glycol, thus:

$$C_3H_6Br_2 + 2CH_3COKo + OH_2 = 2KBr + CH_3COHo + \left.\begin{matrix}C_3H_6\\C_2H_4\end{matrix}\right\} O_2 \text{ and}$$

$$\left.\begin{matrix}C_3H_6\\C_2H_4\end{matrix}\right\} O_2 + KHo = CH_3COKo + C_3H_6H_2O_2.$$

147. What is the weight in grammes of one litre of ethyl gas, measured at 0° C. and 760 mm. pressure?

$(C_2H_5)_2 = C_4H_{10}$ $\qquad C_4 = 48$

$H_{10} = 10$

$2 \,|\, 58$

$29 \times {}^{\cdot}0896 = 2{}^{\cdot}5984$ grm.

148. Having the following materials at your command, could you make from them caproic acid, and if so, how? —Amylic alcohol, quicklime, yellow prussiate of potash, sulphuric acid, water, and potassic carbonate.

Caproic acid, $\left\{\begin{matrix}C(C_4H_9)H_2\\COHo\end{matrix}\right.$, or $\left\{\begin{matrix}C_5H_{11}\\COHo\end{matrix}\right.$.

$K_4FeCy_6 + COKo_2 = 5KCy + CyKO + Fe + CO_2.$

$2KCy + SO_2Ho_2 = K_2SO_4 + 2HCy.$

$2C_5H_{11}HO + 2HCy = 2\left\{\begin{matrix}C_5H_{11}\\CN\end{matrix}\right. + 2H_2O.$

$$2\left\{\begin{matrix}C_5H_{11}\\ CN\end{matrix}\right. + CaH_2O_2 + 2H_2O = \left\{\begin{matrix}(C_5H_{11})_2\\ C_2O_2CaO''\end{matrix}\right. + 2NH_3.$$

$$\left\{\begin{matrix}(C_5H_{11})_2\\ Cao''2CO\end{matrix}\right. + H_2SO_4 = 2\left\{\begin{matrix}C_5H_{11}\\ COHo\end{matrix}\right. + CaSO_4.$$

149. How would you determine quantitatively the percentage of carbon, nitrogen, and hydrogen in a sample of coal?

See analysis.

150. How can acetylene be obtained from coal-gas?

It can be obtained from the incomplete combustion of olefiant gas, the principal luminous constituent of coal-gas, thus: $2C_2H_4 + O_2 = 2OH_2 + 2C_2H_2$.

151. You have given to you sulphuric acid, water, bromine, and ethylic alcohol. State what substances can be prepared from these materials. Give equations and sketches of apparatus.

By mixing the alcohol with four times its volume of strong H_2SO_4 we obtained ethylene as given under that compound. The ethylene unites directly with Br, forming ethylenic dibromide, $C_2H_4Br_2$, by agitating the Br with water and C_2H_4, thus: $C_2H_4 + Br_2 + OH_2 = C_2H_4Br_2 + OH_2$.

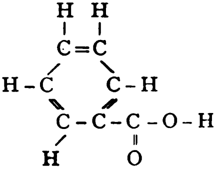
See ether for its production from alcohol and sulphuric acid.

152. Describe the manufacture of oxalic acid from molasses.

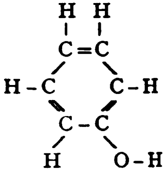
See answer to No. 100.

153. Give the graphic formulæ of, and trace the connection existing between benzoic acid, phenylic alcohol, benzol, essential oil of almonds, and aniline.

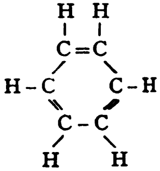
Benzoic acid, $\left\{\begin{matrix}C_6H_5\\ COHo\end{matrix}\right.$,



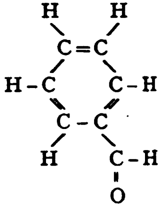
Phenylic alcohol, C_6H_5Ho,



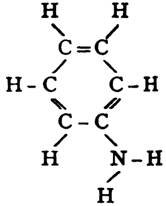
Benzol, C_6H_6,



Oil of bitter almonds, C_6H_5COH,



Aniline, $N(C_6H_5)H_2$,



They all contain the radical C_6H_5.

154. What is the action of hydriodic acid on tart acid and on lactic acid? Give equations.

Tartaric acid, $\left\{\begin{array}{l}COHo\\CHHo\\CHHo\\COHo\end{array}\right. + 4HI = 2I_2 + 2OH_2 + \left\{\begin{array}{l}CC\\CH\\CH\\CC\end{array}\right.$ succinic acid.

Lactic acid, $\left\{\begin{array}{l}\mathrm{CMeHHo}\\ \mathrm{COHo}\end{array}\right. + 2\mathrm{HI} = \mathrm{I}_2 + \mathrm{OH}_2 + \begin{array}{c}\mathrm{C_2H_5}\\ \mathrm{COHo}\end{array}$ propionic acid.

155. An organic compound gave the following numbers on combustion: 0·3355 grm. gave 0·6715 grm. carbonic anhydride, and 0·2745 grm. water: it contained only the elements carbon, hydrogen, and oxygen, and its vapour density was 44 times that of hydrogen. Find its empirical and molecular formulæ.

·6715 × 3 ÷ 11 = ·18314 = C and ·2745 ÷ 9 = ·0305 = H.
·3355 − (·18314 + ·0305) = ·12186 = O
·3355 : ·18134 :: 100 : percentage composition = 54·58 = C
·3355 : ·0305 :: 100 : percentage composition = 9·09 = H
·3355 : ·12186 :: 100 : percentage composition = 36·33 = O

$$\left.\begin{array}{r}54·58 \div 12 = 4·55 \div 2·27 = 2 = \mathrm{C_2}\\ 9·09 \div 1 = 9·09 \div 2·27 = 4 = \mathrm{H_4}\\ 36·33 \div 16 = 2·27 \div 2·27 = 1 = \mathrm{O}\end{array}\right\} = \mathrm{C_2H_4O}, \text{ empirical formula.}$$

$$\begin{array}{l}\mathrm{C_2} = 24\\ \mathrm{H_4} = \ \ 4\\ \mathrm{O} \ = 16\\ \hline \ \ \ \ \ \ \ 44\end{array}$$

As a molecular weight of 44 would give a density of 22, we have to take the double of 44, or 88, as the molecular weight to obtain a density 44 times that of hydrogen, and $\mathrm{C_2H_4O}$ doubled becomes $\mathrm{C_4H_8O_2}$, or $\left\{\begin{array}{l}\mathrm{CEtH_2}\\ \mathrm{COHo}\end{array}\right.$, or $\left\{\begin{array}{l}\mathrm{C(C_2H_5)H_2}\\ \mathrm{COHo}\end{array}\right.$, or $\left\{\begin{array}{l}\mathrm{C_3H_7}\\ \mathrm{COHo}\end{array}\right.$, butyric acid.

156. Explain clearly what is the connection and difference between a ketone and an aldehyde. What is the result obtained by treating a ketone and an aldehyde respectively with nascent hydrogen?

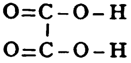
They are both obtained from the fatty acids, the first by the substitution of a monad positive radical, and the second by the substitution of hydrogen instead of the hydroxyl of the acid. By the action of nascent hydrogen the ketones are converted into secondary alcohols, thus: $\begin{array}{l}\mathrm{CH_3}\\ \mathrm{COMe}\end{array} + \mathrm{H_2} = \begin{array}{l}\mathrm{CH_3}\\ \mathrm{CMeHHo}\end{array}$, isopropylic alcohol, and the aldehydes are converted into the corresponding alcohols, thus: $\left\{\begin{matrix}C_nH_{2n+1}\\COH\end{matrix}\right. + H_2 = \left\{\begin{matrix}C_nH_{2n+1}\\CH_2Ho.\end{matrix}\right.$

157. Why are the glycols called dihydric alcohols? Describe what are the products obtained by the gradual oxidation of ethylic glycol.

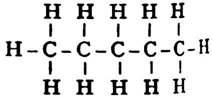
Because the radical with which the hydroxyl is united is a diad. The first product of the oxidation is glycolic acid, $\begin{matrix}CH_2Ho\\CH_2Ho\end{matrix} + O_2 = \begin{matrix}CH_2Ho\\COHo\end{matrix} + OH_2$, and by further oxidation oxalic acid, thus: $\begin{matrix}CH_2Ho\\COHo\end{matrix} + O_2 = \begin{matrix}COHo\\COHo\end{matrix} + OH_2$.

158. Draw the graphic formulæ of the following bodies:—oxalic acid, amylic hydride, allylic alcohol, ethylic glycol, glycerine, methylic ether, acetic aldehyde, lactic acid, and mercuric ethide.

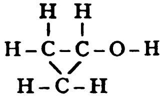
Oxalic acid, $\left\{\begin{matrix}COHo\\COHo\end{matrix}\right.$,



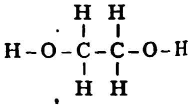
Amylic hydride, $C_5H_{11}H$,



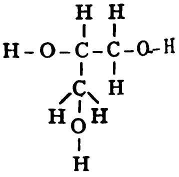
Allylic alcohol, C_3H_5Ho,



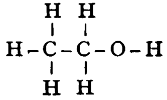
Ethylic glycol, $\begin{matrix}CH_2Ho\\CH_2Ho\end{matrix}$,



Glycerine, $\left\{\begin{matrix}CH_2Ho\\CHHo\\CH_2Ho\end{matrix}\right.$, or $C_3H_5\left\{\begin{matrix}Ho\\Ho,\\Ho\end{matrix}\right.$

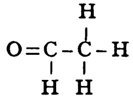


Methylic ether, $\left.\begin{array}{l}CH_3\\CH_3\end{array}\right\}O$,



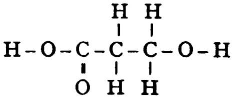
$$H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-O-H$$

Acetic aldehyde, $\begin{array}{l}CH_3\\COH\end{array}$,



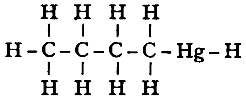
$$O=\underset{H}{C}-\overset{H}{\underset{H}{C}}-H$$

Lactic acid, $\left\{\begin{array}{l}CMeHHo\\COHo\end{array}\right.$,



$$H-O-\underset{O}{C}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-O-H$$

Mercuric ethide, $HgEt_2$,



$$H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-Hg-H$$

159. Describe minutely how you would conduct the antitative analysis of nitro-benzol; give a sketch of the paratus, and state how you would calculate the empiri- l formula and ascertain the molecular or rational for- la of this substance.

See analysis and determination of formulæ.

160. How can you obtain ethylene from carbon and drogen? Give equations.

When the electric arc from a moderately powerful voltaic battery passes between the carbon poles in an atmosphere of hydrogen C_2H_2 is formed, and when this is acted on by nascent hydrogen C_2H_4 is formed, thus: $C_2H_2 + H_2 = C_2H_4$.

161. Can ethylene be converted into ethylic alcohol? so describe how and by what reactions.

$C_2H_4 + H_2SO_4 = C_2H_6SO_4$, and $C_2H_6SO_4 + OH_2 = H_2SO_4 + C_2H_5Ho$.

162. How can ethylic alcohol be transformed succes- ely into propylic, butylic, and amylic alcohols?

Ethylic alcohol, $C_2H_5Ho + H_2SO_4 = HEtSO_4 + OH_2$

$HEtSO_4 + KCN = HKSO_4 + \left\{\begin{matrix} C_2H_5 \\ CN \end{matrix}\right.$.

$\left\{\begin{matrix} C_2H_5 \\ CN \end{matrix}\right. + KHo + OH_2 = NH_3 + \left\{\begin{matrix} C_2H_5 \\ COKo \end{matrix}\right.$, potassic propionate.

$\left\{\begin{matrix} C_2H_5 \\ COHo \end{matrix}\right. + \left\{\begin{matrix} H \\ COKo \end{matrix}\right. = COK_2O_2 + \begin{matrix} C_2H_5 \\ COH \end{matrix}$

$\left\{\begin{matrix} C_2H_5 \\ COH \end{matrix}\right. + H_2 = \left\{\begin{matrix} C_2H_5 \\ CH_2Ho \end{matrix}\right.$, propylic alcohol, from which we can form butylic alcohol and then amylic alcohol in same manner as shown above.

163. What is the weight in grammes of 1 litre of ethylic chloride gas at 0° C. and 760 mm. pressure?

Ethylic chloride, $C_2H_5Cl = 24 + 5 + 35·5 = 64·5 \div 2 = 32·25 \times ·0896 = 2·8896$ grm.

164. Having at your command the following substances, how would you make with them acrylic acid?—Quick-lime, argentic oxide, phosphoric anhydride, water and tallow.

Tallow or stearine, $\left\{\begin{matrix} CH_2 - O - C(C_{17}H_{35})O \\ CH \;\; - O - C(C_{17}H_{35})O \\ CH_2 - O - C(C_{17}H_{35})O \end{matrix}\right. + 3OH_2$, at a high temperature yields glycerine and stearic acid, $\left\{\begin{matrix} CH_2Ho \\ CHHo \\ CH_2Ho \end{matrix}\right. + 3 \left\{\begin{matrix} C_{17}H_{35} \\ COHo \end{matrix}\right.$.

$\begin{matrix} CH_2Ho \\ CHHo \\ CH_2Ho \end{matrix}$ acted on by phosphoric anhydride, splits up into acroleine, $\begin{matrix} CMe''H \\ COH \end{matrix}$, which when oxidized becomes acrylic acid, thus: $C_2H_3COH + O = C_2H_3COHo$, acrylic acid.

165. Having obtained acrylic acid, how could you convert it into propionic acid?

Acrylic acid under the influence of nascent hydrogen produces propionic acid, thus: $\left\{\begin{matrix} CMe''H \\ COHo \end{matrix}\right. + H_2 = \left\{\begin{matrix} CMeH_2 \\ COHo \end{matrix}\right.$, propionic acid.

166. What is the formula of quinine? Describe the ocess of extracting this alkaloid from cinchona bark.

See preparation of quinine.

167. You have given to you some potassic valerate, d are required to prepare from it the radical butyl. ow will you proceed? Give a sketch of the apparatus quired.

By decomposing the solution with a current of electricity from a voltaic battery, which splits up $2\left\{\begin{matrix}C_4H_9\\COKo\end{matrix}\right.$ into $2K + 2C_5H_9O_2$, which latter decomposes immediately into $2CO_2$ and $(C_4H_9)_2$, butyl.

168. What reaction takes place when acetic aldehyde dropped on melted potash?

CH_3COK is formed thus, $2\left\{\begin{matrix}CH_3\\COH\end{matrix}\right. + K_2 = 2\left\{\begin{matrix}CH_3\\COK\end{matrix}\right. + H_2$.

169. Describe minutely how you would prepare silicic hide. Give a sketch of the apparatus you would employ.

See organo-silicon compounds.

170. How would you perform the ultimate analysis of inine? By what tests can you identify this substance?

See analysis of nitrogenous bodies and the identification of quinine.

171. In the investigation of an organic compound the llowing data were obtained:—Carbon 62·07, hydrogen ·35, and oxygen 27·58.

$$\left.\begin{matrix}62{\cdot}07 \div 12 = 5{\cdot}1725 \div 1{\cdot}724 = 3\\10{\cdot}35 \div 1 = 10{\cdot}35 \div 1{\cdot}724 = 6\\27{\cdot}58 \div 16 = 1{\cdot}724 \div 1{\cdot}724 = 1\end{matrix}\right\} C_3H_6O,$$

empirical formula $C_3H_6O = 36 + 6 + 16 = 58$, and if this is the molecular formula, then $58 \div 2 = 29 \times {\cdot}0693$ should be equal 4·04, but it is only equal 2·0097, therefore twice C_3H_6O, or $C_6H_{12}O_2 = 72 + 12 + 32 = 116$, is the molecular formula, since $116 \div 2 = 58 \times {\cdot}0693 = 4{\cdot}04$.

172. Develop completely the formula $CBuH_3$, and

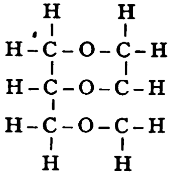
reduce to a single line the formula, $\left\{\begin{array}{l}CH_3\\CH_2\\CH_2\\CH_2\\CH_2\\CH_2\\CH_2\\CH_3\end{array}\right.$

$CBu\,H_3 = CH_3\,C_4\,H_9 = CH_3\,CH_2\,C_3\,H_7 = CH_3\,CH_2\,CH_2\,C_2\,H_5 = CH_3CH_2CH_2CH_2CH_3$.

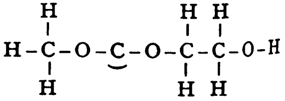
And the formula, when reduced to a single line by adding CH_2 to CH_3 to obtain C_2H_5, and adding CH_2 again to C_2H_5 to obtain C_3H_7, and so on till all have been added, we obtain $C_8H_{17}H$.

173. Give the graphic formulæ of the following bodies:—Glycylic ether, monacetic glycol, pyruvic acid, and boric methide.

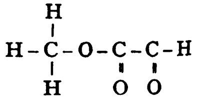
Glycylic ether, $\left\{\begin{array}{l}CH_2-O-H_2C\\CH\ -O-H\ C,\\CH_2-O-H_2C'\end{array}\right.$



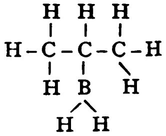
Monacetic glycol, $\begin{array}{l}CH_2Ho\\CH_2-O-CMeO,\end{array}$



Pyruvic acid, $\left\{\begin{array}{l}COMe\\COHo'\end{array}\right.$



Boric methide, $B(CH_3)_8$,



174. Define the following families of organic compounds:—Radicals, alcohols, ethers, aldehydes, acids, anhydrides, ketones, and ethereal salts.

See definitions.

175. Give the names and formulæ of some of the more important natural alkaloids.

See the alkaloids.

176. The following data are known respecting an organic compound: the percentage composition of carbon, hydrogen, and nitrogen are respectively 38·71, 16·13, and 45·16. Vapour density = 15·1; H = 1. Required the rational formula and name of the compound.

$$\left.\begin{array}{l} 38{\cdot}71 \div 12 = 3{\cdot}225 \div 3{\cdot}225 = 1 \\ 16{\cdot}13 \div 1 = 16{\cdot}13 \div 3{\cdot}225 = 5 \\ 45{\cdot}16 \div 14 = 3{\cdot}225 \div 3{\cdot}225 = 1 \end{array}\right\} CH_5N.$$

$CH_5N = 12 + 5 + 14 = 31 \div 2 = 15{\cdot}5$ times the density of hydrogen, or nearly 15·1, so that CH_5N, or $N(CH_3)H_2$, is the rational formula.

177. Having at your command the following substances, how would you make from them diethylamine?—Ethylic alcohol, ammonia, iodine, phosphorus, and caustic potash.

By placing in a retort two parts by weight of ethylic alcohol and one of amorphous phosphorus, and then introducing five parts of iodine and distilling in a water bath, thus: $3C_2H_5Ho + P + I_3 = 3C_2H_5I + POHH_2O_2$, and $EtI + NH_3 = NEtH_3I$, ethylammonic iodide, and $NEtH_3I + KHo = NEtH_2 + KI + OH_2$ and $NEtH_2 + EtI = NEt_2H_2I$, diethylammonic iodide, then $NEt_2H_2I + KHo = KI + OH_2 + NEt_2H$, diethylamine.

178. How would you perform the ultimate organic analysis of strychnine? How can you qualitatively recognize this alkaloid?

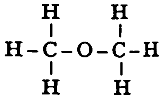
See analysis of nitrogenous bodies and identifications.

179. Give the graphic formula of a member of each of

the following series of organic bodies:—Dyad positive radicals, ethers of the monacid, diacid, and triacid alcohols, aldehydes, acids of the acrylic series, anhydrides, ketones, and organometallic bodies.

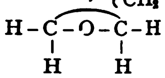
Ethylene, a diad positive radical, given above.

Methyl ether, $\left\{\begin{array}{l}CH_3\\O\\CH_3\end{array}\right.$, an ether of a monacid alcohol,



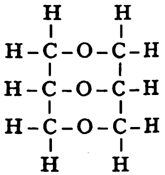
$$\begin{array}{ccccccccc} & & H & & & & H & & \\ & & | & & & & | & & \\ H & - & C & - & O & - & C & - & H \\ & & | & & & & | & & \\ & & H & & & & H & & \end{array}$$

Ethylenic ether from a diacid alcohol, $\left\{\begin{array}{l}CH_2\\CH_2\end{array}\right.O$,



$$\begin{array}{ccccccccc} H & - & C & - & \overset{\frown}{O} & - & C & - & H \\ & & | & & & & | & & \\ & & H & & & & H & & \end{array}$$

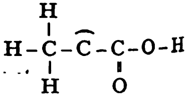
Glycylic ether, $\left\{\begin{array}{l}CH_2-O-H_2C\\CH\ \ -O-HC,\\CH_2-O-H_2C\end{array}\right.$



$$\begin{array}{ccccccccc} & & H & & & & H & & \\ & & | & & & & | & & \\ H & - & C & - & O & - & C & - & H \\ & & | & & & & | & & \\ H & - & C & - & O & - & C & - & H \\ & & | & & & & | & & \\ H & - & C & - & O & - & C & - & H \\ & & | & & & & | & & \\ & & H & & & & H & & \end{array}$$

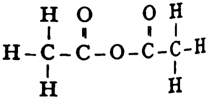
Acetic aldehyde given above.

Acrylic acid, $\left\{\begin{array}{l}C_2H_3\\COHo\end{array}\right.$,



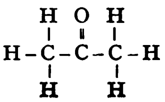
$$\begin{array}{ccccccccccc} & & H & & & & & & & & \\ & & | & & & & & & & & \\ H & - & C & - & \overset{\frown}{C} & - & C & - & O & - & H \\ & & | & & & & \| & & & & \\ & & H & & & & O & & & & \end{array}$$

Acetic anhydride, $\left\{\begin{array}{l}C(Me)O\\O\\C(Me)O\end{array}\right.$,



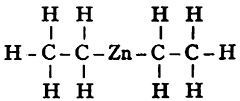
$$\begin{array}{ccccccccccccc} & & H & & O & & & & O & & H & & \\ & & | & & \| & & & & \| & & | & & \\ H & - & C & - & C & - & O & - & C & - & C & - & H \\ & & | & & & & & & & & | & & \\ & & H & & & & & & & & H & & \end{array}$$

Acetone, $\left\{\begin{array}{l}CH_3\\COMe\end{array}\right.$,



$$\begin{array}{ccccccccc} & & H & & O & & H & & \\ & & | & & \| & & | & & \\ H & - & C & - & C & - & C & - & H \\ & & | & & & & | & & \\ & & H & & & & H & & \end{array}$$

Zincic ethide, $Zn\,Et_2$,



$$\begin{array}{ccccccccccc} & & H & & H & & & & H & & H & & \\ & & | & & | & & & & | & & | & & \\ H & - & C & - & C & - & Zn & - & C & - & C & - & H \\ & & | & & | & & & & | & & | & & \\ & & H & & H & & & & H & & H & & \end{array}$$

180. Describe the preparation of ethylic chloride.

See the ethers.

181. What substance is produced when nitro-benzol is added to a mixture of acetic acid and iron-filings? Describe the chemical changes that occur.

See aniline.

182. When alcohol is heated with a solution of bleaching-powder what is the name and formula of the volatile body produced?

See chloroform.

183. How is acetone prepared, what are its chief properties, and what is the action of nascent hydrogen upon this substance?

Nascent hydrogen converts acetone into isopropylic alcohol. See the ketones.

184. Describe the chemical change which is produced by the addition of phosphoric oxychloride to potassic acetate.

$$3\left\{\begin{matrix}CH_3\\COKo\end{matrix}\right. + POCl_3 = 3\left\{\begin{matrix}CH_3\\COCl\end{matrix}\right. + POKo_3.$$

185. You have given to you acetylene, zinc, ammonia, sulphuric acid, and water. What organic substances can you prepare from these materials? Give equations and sketches of apparatus.

By the action of the nascent hydrogen evolved by the action of zinc on ammonia on the acetylene ethylene C_2H_4 is obtained, and the sulphuric acid converts ethylene into sulphovinic acid, thus: $C_2H_4 + H_2SO_4 = HEtSO_4$ and $HEtSO_4 + OH_2 = H_2SO_4 + EtHo$, ethylic alcohol. Then from the alcohol, ether, aldehyde, acetic acid, &c., can be prepared as shown above.

186. What chemical changes occur when ethylic iodide is added to sodic ethide?

$C_2H_5I + C_2H_5Na = NaI + C_2H_4 + C_2H_5H.$

187. How is potassic ferrocyanide obtained, and what are its chief properties?

By placing a mixture of iron-filings and a solution of potassic cyanide in contact with the air oxygen is absorbed and potassic ferrocyanide produced, thus: $Fe + 6KCy + OH_2 + O = K_4FeCy_6 + 2KHo.$

By digesting potassic cyanide with ferrous sulphate, thus: $FeS + 6KCy + K_4FeCy_6 + SK_2.$

On a manufacturing scale it is prepared by fusing nitrogenous animal matter with potassic carbonate and iron-filings in an iron vessel, lixiviating the resulting mass with water, and crystallizing.

Its chief properties are as follows, viz., when fused with potassic carbonate, potassic cyanide and cyanate are formed, thus: $K_4FeCy_6 + COK_2O_2 = 5KCy + Cy KO$, &c. By mixing a solution of K_4FeCy_6 with ether and HCl hydroferrocyanic is precipitated, thus: $FeCy_6 K_4 + 4HCl = 4KCl + FeCy_6H_4.$

K_4FeCy_6 produces with a solution of ferrous salts a light blue precipitate, which rapidly becomes dark blue in contact with the air, thus: $K_4FeCy_6 + FeSO_4 = Fe' Cy_6Fe''K_2$ (the light blue precipitate) $+ K_2SO_4.$

With ferric salts it gives Prussian blue, thus: $3Fe Cy_6K_4 + 2Fe_2Cl_6 = 3Fe''Cy_2, 2Fe'''_2Cy_6 + 12KCl.$

With cupric salts it gives a red precipitate of cupric ferrocyanide, thus: $K_4FeCy_6 + 2CuSO_4 = 2K_2SO_4 + Cu''_2Fe''Cy_6.$

188. What takes place when the essential oil of bitter almonds is boiled with alcoholic solution of potash? Give an equation.

Potassic benzoate is formed, thus: $\begin{array}{c}C_6H_5\\COH\end{array} + KHo = \left\{\begin{array}{l}C_6H_5\\COKo\end{array}\right. + H_2.$

189. Give the name and constitutional formula of a

ember of each of the following families of organic bodies: -Dyad positive radicals, haloid ethers, aldehydes, anhyrides, ketones, organo-boron compounds, and organoetallic bodies.

(1.) Ethylene, $\left\{\begin{matrix}\mathrm{CH_2}\\ \mathrm{CH_2}\end{matrix}\right.$.

(2.) Ethylic chloride, $\left\{\begin{matrix}\mathrm{CH_3}\\ \mathrm{CH_2Cl}\end{matrix}\right.$, and $\left\{\begin{matrix}\mathrm{CH_2Br}\\ \mathrm{CH_2Br}\end{matrix}\right.$, ethylenic bromide.

(3.) Acetic aldehyde, $\begin{matrix}\mathrm{CH_3}\\ \mathrm{COH}\end{matrix}$.

(4.) Acetic anhydride, $\left\{\begin{matrix}\mathrm{CMeO}\\ \mathrm{O}\\ \mathrm{CMeO}\end{matrix}\right.$.

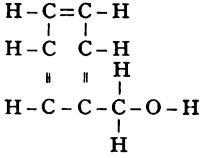
(5.) Acetone, $\left\{\begin{matrix}\mathrm{CH_3}\\ \mathrm{COMe}\end{matrix}\right.$.

(6.) Boric ethide, $B(C_2H_5)_3$.

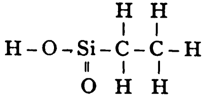
(7.) Zincic ethide, $ZnEt_2$.

190. Give the graphic formulæ of the following organic ompounds:—Glycerine, benzylic alcohol, pyruvic acid, ropyl, silicopropionic acid, and toluidine.

Benzylic alcohol, $\left\{\begin{matrix}\mathrm{C_6H_5}\\ \mathrm{CH_2Ho}\end{matrix}\right.$,



Silicopropionic acid, $\left\{\begin{matrix}\mathrm{CMeH_2}\\ \mathrm{SiOHo}\end{matrix}\right.$,



$$\begin{array}{ccccccccccc} & & & & & & \mathrm{H} & & \mathrm{H} & & \\ & & & & & & | & & | & & \\ \mathrm{H} & - & \mathrm{O} & - & \mathrm{Si} & - & \mathrm{C} & - & \mathrm{C} & - & \mathrm{H} \\ & & & & \| & & | & & | & & \\ & & & & \mathrm{O} & & \mathrm{H} & & \mathrm{H} & & \end{array}$$

The others have been given.

191. How would you determine the molecular formula a monobasic organic acid and of an organic base?

See analysis of organic bodies containing C, H, and O, and C, H, O, and N.

192. You are required to transform 100 grm. of ethylene o ethylic alcohol; how would you do it, and what ight of ethylic alcohol will you obtain?

$C_2H_4 + H_2SO_4 = HEtSO_4$ and $HEtSO_4 + OH_2 = H_2SO_4 + EtHo$.

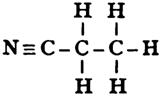
$C_2 = 24$	$C_2 = 24$	$: 23 :: 100 : 164\frac{2}{7}$ grm.
$H_4 = 4$	$H_6 = 6$	
—	$O = 16$	
$2)28$	—	
—	$2)46$	
14	—	
	23	

193. What compound is formed when cold dilute nitric acid acts upon glycol, and how does the reaction differ when the acid is hot?

In the first case glycollic acid is formed, thus: $\begin{matrix} CH_2Ho \\ CH_2Ho \end{matrix} + O_2 = \left\{ \begin{matrix} CH_2Ho \\ COHo \end{matrix} \right.$, glycollic acid $+ OH_2$; and in the other case oxalic acid is formed, thus: $\begin{matrix} CH_2Ho \\ CH_2Ho \end{matrix} + O_4 = \left\{ \begin{matrix} COHo \\ COHo \end{matrix} \right. + 2OH_2$.

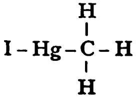
194. Give the graphic formulæ of the following compounds:—Allylamine, mercuric methiodide, stannic methodiniodide, malic acid, and tartaric acid.

Allylamine, $N(C_3H_5)H_2$,



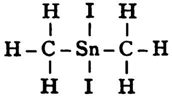
$$N\equiv C-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{H}{C}}-H$$

Mercuric methiodide, $HgMeI$,



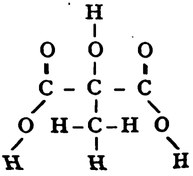
$$I-Hg-\underset{H}{\overset{H}{C}}-H$$

Stannic methodiniodide, $SnMe_2I_2$,

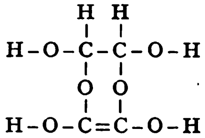


$$H-\underset{H}{\overset{H}{C}}-\underset{I}{\overset{I}{Sn}}-\underset{H}{\overset{H}{C}}-H$$

Malic acid, $\left\{ \begin{matrix} COHo \\ CMeHo, \\ COHo \end{matrix} \right.$



Tartaric acid, $\left\{\begin{array}{l}COHo\\CHHo\\CHHo\\COHo\end{array}\right.$'



$$\begin{array}{c}H\quad H\\ |\quad\ |\\ H-O-C-C-O-H\\ |\quad\ |\\ O\quad O\\ |\quad\ |\\ H-O-C=C-O-H\end{array}$$

195. What chemical change takes place when oleic acid is dropped upon excess of melted potash? Give an equation.

It gives potassic acetate and potassic palmitate, thus:
$\left\{\begin{array}{l}C(C_{16}H_{32})''H\\COHo\end{array}\right. + 2KHo = \left\{\begin{array}{l}CH_3\\COKo\end{array}\right. + \left\{\begin{array}{l}C(C_{14}H_{29})H_2\\COKo\end{array}\right. + H_2.$

196. How would you prepare allylic alcohol and then transform it into propylic alcohol?

Glycerine when submitted to the action of di-phosphorous tetriodide yields allylic iodide: $P_2I_4 + 2\left\{\begin{array}{l}CH_2Ho\\CHHo\\CH_2Ho\end{array}\right. = 2POHH_2O_2 + I_2 + 2\left\{\begin{array}{l}CH_2\\CH\\CH_2I.\end{array}\right.$

The allylic iodide is then decomposed by argentic oxalate, when allylic oxalate is formed: $2AllI + \left\{\begin{array}{l}COAgo\\COAgo\end{array}\right. = \left\{\begin{array}{l}COAllo\\COAllo\end{array}\right. + 2AgI.$

The allylic oxalate is next decomposed by ammonia, when oxamide and allylic alcohol are produced: $\left\{\begin{array}{l}COAllO\\COAllO\end{array}\right. + 2NH_3 = \left\{\begin{array}{l}CON'''H_2\\CON'''H_2\end{array}\right. + 2AllHo,$ allylic alcohol.

197. What acid is produced when di-bromo-succinate of silver is heated in contact with water? Give an equation.

Inactive tartaric acid, $\left\{\begin{array}{l}COAgO\\CHBr\\CHBr\\COAgO\end{array}\right. + 2OH_2 = 2AgBr + \left\{\begin{array}{l}COHo\\CHHo\\CHHo\\COHo\end{array}\right.$·

198. Give the law regulating the basicity of organic acids, and state the basicity of the following acids:—

Acrylic acid, malonic acid, fumaric acid, malic acid, benzoic acid, and tartaric acid.

An organic acid containing *n* semi-molecules of oxatyl is *n* basic.

Acrylic acid, $\left\{\begin{matrix}CMe''H\\COHo\end{matrix}\right.$, is monobasic.

Malonic acid, $\left\{\begin{matrix}COHo\\CH_2\\COHo\end{matrix}\right.$, is dibasic.

Fumaric acid, $C_2H_2(COHo)_2$, is dibasic.

Malic acid, $\left\{\begin{matrix}COHo\\CMeHo\\COHo\end{matrix}\right.$, is dibasic, and contains one atom of non-oxatylic hydroxyl.

Benzoic acid, $\left\{\begin{matrix}C_6H_5\\COHo\end{matrix}\right.$, is monobasic.

Tartaric acid, $\left\{\begin{matrix}COHo\\CHHo\\CHHo\\COHo\end{matrix}\right.$, is dibasic, and contains two atoms of non-oxatylic hydroxyl.

199. What compounds are obtained by digesting together at 100° C. amylic iodide, water, and zinc? Express the chemical change by an equation.

Zinc oxide, zinc iodide, and amyl hydride, thus:

$$2C_5H_{11}I + OH_2 + 2Zn = ZnO + ZnI_2 + 2\left\{\begin{matrix}C_5H_{11}\\H\end{matrix}\right..$$

200. Give an account of the compounds formed when carbon monoxide (carbonic oxide) and caustic potash are heated together.

CO and KHo when heated together for two days at 100° C. form potassic formiate, $CO + KHo = HCOKo$, and when the potassic formiate is heated potassic oxalate is formed and hydrogen given off: $2HCOKo = \left\{\begin{matrix}COKo\\COKo\end{matrix}\right. + H_2$.

See formic acid and oxalic acid.

201. What means would you adopt for ascertaining the

olecular weight of quinine? The simplest formula of is substance is $C_{10}H_{12}NO$.

See determination of rational formulæ.

202. What is the composition and what the properties the organic compound formed by the action of ethylene bromide upon silver acetate?

$C_2H_4Br_2 + 2CH_3COAgo = C_2H_4O_2(COMe)_2$, ethylenic diacetate, or glycol diacetate $+ 2AgBr$.

It is a liquid, neutral and colourless, heavier than water. It gives a faint acetic odour when heated. It dissolves freely in alcohol, and is but slightly soluble in water.

When acted upon by KHo at a temperature of about 180° C. for a few hours glycol is produced: $C_2H_4O_2(COMe)_2 + 2KHo = 2CH_3COKo + C_2H_4H_2O_2$, glycol.

203. Give the name and formula of the compound proıced when glycerine is heated (1), with phosphorous dide, and (2), with hydriodic acid.

Allylic iodide, thus: $2C_3H_5H_3O_3 + P''_2I_4 = I_2 + 2POHH_2O_2 + 2C_3H_5I$.

Isopropylic iodide, thus: $C_3H_5H_3O_3 + 5HI = 2I_2 + 3OH_2 + C_3H_5I$.

204. Describe the preparation of stannic ethide.

By acting on ethylic iodide with a tin sodium alloy: $4C_2H_5I + SnNa_4 = SnEt_4 + 4NaI$.

See organo-metallic bodies.

205. What are the usual impurities of coal-gas? Deribe the processes adopted for their removal.

See coal-gas.

206. Give the formula of silicon ethyl and silico-nonyl liconylic) alcohol. Why is this name given to the latter mpound?

Silicic ethide, $SiEt_4$.

Siliconylic alcohol, $\left\{\begin{matrix}CMeHHo\\SiEt_3\end{matrix}\right.$.

The latter is so called because when Si is taken equal to C we have $\frac{CMeHHo}{SiEt_3} = \frac{C_2H_4Ho}{CC_6H_{15}} = C_9H_{19}Ho$ = nonylic alcohol, because C_9H_{19} is the radical nonyl.

207. Explain the action of hydriodic acid upon malic acid.

$$\text{Malic acid, } \left\{\begin{array}{l} COHo \\ CHHo \\ CH_2 \\ COHo \end{array}\right. + 2HI = I_2 + OH_2 + \left\{\begin{array}{l} COHo \\ CH_2 \\ CH_2 \\ COHo \end{array}\right. \text{, succinic acid.}$$

208. Develop the formulæ Ay_2, $CBuEtH_2$, and $(CPrEtMe)_2$.

$Ay_2 = (C_5H_{11})_2$ and $C_5H_{11} = CH_2C_4H_9 = CH_2CH_2C_3H_7 = CH_2CH_2CH_2C_2H_5 = CH_2CH_2CH_2CH_2CH_3$ and $(CH_2CH_2CH_2CH_2CH_3)_2 = Ay_2 = CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$.

$CBuEtH_2 = CC_4H_9C_2H_5H_2 = CCH_2C_3H_7CH_2CH_3H_2 = CH_2CH_2CH_2C_2H_5CH_2CH_3 = CH_2CH_2CH_2.CH_2CH_3CH_2CH_3 = CH_3CH_2CH_2CH_2CH_2CH_3$.

And $(CPrEtMe)_2$ and $CPrEtMe = CC_3H_7C_2H_5CH_3 = CCH_2C_2H_5CH_2CH_3CH_3 = CCH_2CH_2CH_3CH_2CH_3CH_3 = CH_3C_2H_3CH_2CH_2CH_2CH_3$.

And $(CH_3C_2H_3CH_2CH_2CH_2CH_3)_2 = (CPrEtMe)_2$, and as $(CH_3)_2$ and $(C_2H_3)_2 = C_6H_{12} = (CH_2)_6$ we have it $= CH_3CH_3CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_2CH_3$.

209. What changes take place when nascent hydrogen acts upon (1) acetone, (2) acrylic acid, (3) acetic aldehyde, and (4) pyruvic acid?

Acetone, $\begin{array}{l} CH_3 \\ COMe \end{array} + H_2 = \left\{\begin{array}{l} CH_3 \\ CMeHHo \end{array}\right.$, isopropylic alcohol.

Acrylic acid, $\left\{\begin{array}{l} C_2H_3 \\ COHo \end{array}\right. + H_2 = \left\{\begin{array}{l} C_2H_5 \\ COHo \end{array}\right.$, propionic acid.

Acetic aldehyde, $\left\{\begin{array}{l} CH_3 \\ COH \end{array}\right. + H_2 = \left\{\begin{array}{l} CH_3 \\ CH_2Ho \end{array}\right.$, ethylic alcohol.

Pyruvic acid, $\left\{\begin{array}{l} COMe \\ COHo \end{array}\right. + H_2 = \left\{\begin{array}{l} CMeHHo \\ COHo \end{array}\right.$, lactic acid.

210. Explain with equations the action of acetyl chloride upon potassium acetate, and describe the properties of the resulting organic compound.

Acetyl chloride, $\left\{\begin{matrix}CH_3\\COCl\end{matrix}\right. + \begin{matrix}CH_3\\COKo\end{matrix} = KCl + \left\{\begin{matrix}COMe\\COMe\end{matrix}\right.O$, acetic anhydride.

See the anhydrides for properties.

211. 0·213 grm. of a carbinol yielded on combustion 0·566 grm. CO_2 and 0·265 grm. H_2O. Required its empirical formula.

$\cdot566 \times 3 \div 11 = \cdot15436 = C$ and $\cdot265 \div 9 = \cdot02944 = H$

$\cdot213 - (\cdot15436 + \cdot02944) = \cdot0292 = O.$

$$\left.\begin{array}{l}\cdot213 : \cdot15436 :: 100 : 72\cdot49 = C \div 12 = 6\cdot04 \div \cdot86 = 7\\ \cdot213 : \cdot02944 :: 100 : 13\cdot8 = H \div 1 = 13\cdot8 \div \cdot86 = 16\\ \cdot213 : \cdot0292 :: 100 : 13\cdot71 = O \div 16 = \cdot86 \div \cdot86 = 1\end{array}\right\} C_7H_{16}O.$$

$C_7H_{16}O$ is the empirical formula.

212. How is zinc ethyl prepared? State its most important properties.

See organo-metallic compounds.

213. A compound ammonia has the empirical formula C_3H_9N; what steps would you take to ascertain its constitution?

See the determination of rational formulæ.

214. If you were required to transform 10 grm. of pyruvic acid into lactic acid how would you do it, and what weight of lactic acid would be produced?

Pyruvic acid absorbs hydrogen, becoming lactic acid:

$\left\{\begin{matrix}COMe\\COHo\end{matrix}\right. + H_2 = \begin{matrix}CMeHHo\\COHo\end{matrix}$, lactic acid.

Pyruvic acid, $\left\{\begin{array}{l}C_3 = 36\\H_4 = 4\\O_3 = 48\end{array}\right.$ $\overline{88}$ Lactic acid, $\left\{\begin{array}{l}C_3 = 36\\H_6 = 6\\O_3 = 48\end{array}\right.$ $\overline{90}$

88 : 90 :: 10 : $10\frac{5}{22}$ grm. of lactic acid.

215. Give the name and composition of the several

constituents of coal-gas, dividing them into illuminating agents, diluents, and impurities.

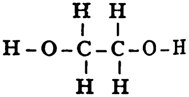
See coal-gas.

216. Give the graphic and symbolic formulæ of the following compounds: glycol, ethylic oxide, ethylenic oxide, chlorhydric glycol, essential oil of bitter almonds, glyoxylic acid, methyl-propyl ketone, and stibmethine.

Glycol, $\begin{matrix} CH_2Ho \\ CH_2Ho \end{matrix}$, is already given.

Ethylic oxide or ether and ethylenic oxide or ether are already given.

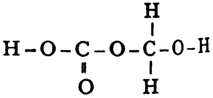
Chlorhydric glycol, $\left\{ \begin{matrix} CH_2Ho \\ CH_2Cl \end{matrix} \right.$,



$$\begin{array}{ccccccccccc} & & & & H & & H & & & & \\ & & & & | & & | & & & & \\ H & - & O & - & C & - & C & - & O & - & H \\ & & & & | & & | & & & & \\ & & & & H & & H & & & & \end{array}$$

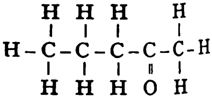
The essential oil of bitter almonds is given above.

Glyoxylic acid, $\left\{ \begin{matrix} CHH_2O_2 \\ COHo \end{matrix} \right.$,



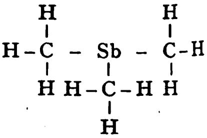
$$\begin{array}{ccccccccccccc} & & & & & & & & H & & & & \\ & & & & & & & & | & & & & \\ H & - & O & - & C & - & O & - & C & - & O & - & H \\ & & & & \| & & & & | & & & & \\ & & & & O & & & & H & & & & \end{array}$$

Methyl-propyl ketone, $\left\{ \begin{matrix} CEtH_2 \\ COMe \end{matrix} \right.$,



$$\begin{array}{ccccccccccccc} & & H & & H & & H & & & & H & & \\ & & | & & | & & | & & & & | & & \\ H & - & C & - & C & - & C & - & C & - & C & - & H \\ & & | & & | & & | & & \| & & | & & \\ & & H & & H & & H & & O & & H & & \end{array}$$

Stibmethine, $SbMe_3$,



$$\begin{array}{ccccccccc} & & H & & & & H & & \\ & & | & & & & | & & \\ H & - & C & - & Sb & - & C & - & H \\ & & | & & | & & | & & \\ & & H & H - & C & - H & H & & \\ & & & & | & & & & \\ & & & & H & & & & \end{array}$$

217. Explain the meaning which you attach to the terms "saturated" and "non-saturated" as applied to organic compounds. Illustrate your explanation by examples.

See the theory of compound organic radicals.

218. What compounds are formed when cyanhydric

ycol is boiled with alcoholic solution of potash? Give equation.

Cyanhydric glycol, $\left\{\begin{matrix}CH_2Ho\\CH_2CN\end{matrix}\right. + KHo + OH_2 = NH_3 +$ $\left\{\begin{matrix}CH_2Ho\\CH_2\\COKo\end{matrix}\right.$, potassic paralactate.

219. What chemical changes take place when zinc-ethyl is added in excess to boric ethylate? Give an uation.

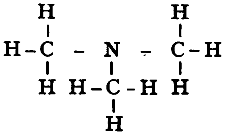
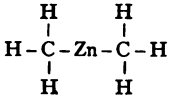
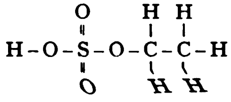
$$2BEt_3O_3 + 3ZnMe_2 = 2BEt_3 + 3ZnMe_2O_2.$$

220. Starting with the elements carbon and hydrogen, scribe a series of synthetical processes by which you n produce in succession acetylene, olefiant gas, alcohol, d acetic acid without the use of any compound derived om the organic kingdom.

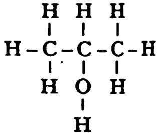
This question is answered elsewhere.

221. Give the constitutional formulæ, both symbolic d graphic, of the following compounds:—Ethyl, triethylamine, zinc methyl, sulphovinic acid, ethylene, isoopylic alcohol, allylic alcohol.

Ethyl, allylic alcohol, and ethylene are given elsewhere.

	Symbolic Formula.	Graphic Formula.
Trimethylamine,	$N(CH_3)_3$	 $\begin{array}{ccccccccc} & & H & & & & H & & \\ & & \vert & & & & \vert & & \\ H & - & C & - & N & - & C & - & H \\ & & \vert & & \vert & & \vert & & \\ & & H & & H-C-H & & H & & \\ & & & & \vert & & & & \\ & & & & H & & & & \end{array}$
Zinc methyl,	$Zn(CH_3)_2$	 $\begin{array}{ccccccccc} & & H & & & & H & & \\ & & \vert & & & & \vert & & \\ H & - & C & - & Zn & - & C & - & H \\ & & \vert & & & & \vert & & \\ & & H & & & & H & & \end{array}$
Sulphovinic acid,	SO_2HOEtO	 $\begin{array}{ccccccccccccc} & & & & O & & & & H & & H & & \\ & & & & \Vert & & & & \vert & & \vert & & \\ H & - & O & - & S & - & O & - & C & - & C & - & H \\ & & & & \Vert & & & & \vert & & \vert & & \\ & & & & O & & & & H & & H & & \end{array}$

Isopropylic alcohol, $\left\{\begin{matrix}CH_3\\CMeHHO\end{matrix}\right.$



$$\begin{array}{ccccccccc} & & H & & H & & H & & \\ & & | & & | & & | & & \\ H & - & C & - & C & - & C & - & H \\ & & | & & | & & | & & \\ & & H & & O & & H & & \\ & & & & | & & & & \\ & & & & H & & & & \end{array}$$

222. Give the evidence on which is founded the following constitutional formula for acetic acid:—CMeO (HO).

Acetic acid is obtained by oxidizing alcohol, thus: $\left\{\begin{matrix}CH_3\\CH_2HO\end{matrix}\right. + O_2 = \begin{matrix}CH_3\\COHo\end{matrix} + OH_2$. The oxidation substitutes H_2 by O, leaving the monad positive radical CH_3 or Me united with a semimolecule of oxatyl, $(COHo)_2$, so that it is a monobasic acid.

223. Give the name and constitutional formula of a normal monacid alcohol, a secondary monacid alcohol, and a tertiary monacid alcohol, and state how these classes of alcohols differ in their behaviour under the influence of oxidizing agents.

Normal monacid alcohol, ethylic alcohol, C_2H_5Ho or $\left\{\begin{matrix}CH_3\\CH_2Ho\end{matrix}\right.$.

Secondary monacid alcohol, isopropylic alcohol, $\left\{\begin{matrix}CH_3\\C(CH_3)\end{matrix}\right. HHo$.

Tertiary monacid alcohol, pseudobutylic alcohol, CMe_3Ho.

The normal monacid alcohols yield acids on oxidation, but the secondary monacid alcohols yield ketones instead.

224. Describe the relations existing between the acetic, acrylic, and lactic series of acids, and state how the acids of one series can be transformed into those of the other series. Give an instance of isomerism in any one of these series of acids.

Acetic series.

$$\left\{\begin{matrix}C(C_nH_{2n+1})H_2\\COHo\end{matrix}\right. + Cl_2 = \begin{matrix}C(C_nH_{2n+1})HCl\\COHo\end{matrix} + HCl$$

$\left\{\begin{matrix}\mathrm{C(C_nH_{2n+1})HCl}\\ \mathrm{COHo}\end{matrix}\right. + \mathrm{KHo} = \mathrm{KCl} + \left\{\begin{matrix}\mathrm{C(C_nH_{2n+1})HHo},\\ \mathrm{COHo}\end{matrix}\right.$ an acid of the lactic series.

Lactic series.

$\left\{\begin{matrix}\mathrm{C(C_nH_{2n+1})\ (C_mH_{2m+1})\ Ho}\\ \mathrm{COHo}\end{matrix}\right. + 2\mathrm{HI} = \mathrm{I_2} + \mathrm{OH_2} + \left\{\begin{matrix}\mathrm{C(C_nH_{2n+1})(C_mH_{2m+1})H}\\ \mathrm{COHo}\end{matrix}\right.$, an acid of the acetic series.

Acrylic series.

$\left\{\begin{matrix}\mathrm{C(C_nH_{2n})''(C_mH_{2m+1})}\\ \mathrm{COHo}\end{matrix}\right. + 2\mathrm{KHo} = \mathrm{H_2} + \left\{\begin{matrix}\mathrm{C(C_{n-2}H_{2n-3})H_2}\\ \mathrm{COKo}\end{matrix}\right. + \left\{\begin{matrix}\mathrm{C(C_mH_{2m+1})H_2}\\ \mathrm{COKo}\end{matrix}\right.$, potassic salts of the acetic series.

Lactic acid is isomeric with paralactic acid.

Lactic acid is represented by the formula $\left\{\begin{matrix}\mathrm{CMeHHo}\\ \mathrm{COHo}\end{matrix}\right.$, and paralactic by $\left\{\begin{matrix}\mathrm{CH_2Ho}\\ \mathrm{CH_2(COHo)}\end{matrix}\right.$.

Propylic glycol, $\left\{\begin{matrix}\mathrm{CMeHHo}\\ \mathrm{CH_2Ho}\end{matrix}\right. + \mathrm{O_2} = \mathrm{OH_2} + \left\{\begin{matrix}\mathrm{CMeHHO}\\ \mathrm{COHo}\end{matrix}\right.$ lactic acid.

Cyanhydric glycol, $\left\{\begin{matrix}\mathrm{CH_2Ho}\\ \mathrm{CH_2(CN)}\end{matrix}\right. + \mathrm{KHo} + \mathrm{OH_2} = \mathrm{NH_3} + \left\{\begin{matrix}\mathrm{CH_2Ho}\\ \mathrm{CH_2COKo}\end{matrix}\right.$, paralactic acid.

225. Describe a method by which you can obtain propionic acid from ethylic alcohol.

This has been answered elsewhere.

226. Give a method for the preparation of the following organic substances: Cacodyl, zinc ethyl, triethyl phosphine propione, lactic acid, paralactic acid.

Cacodyl may be prepared by acting on an alloy of arsenic and sodium by methylic iodide, thus: $\mathrm{As_2Na_4} + 4\mathrm{MeI} = 4\mathrm{NaI} + \mathrm{As_2Me_4}$ (cacodyl).

Zinc ethide. See organo-metallic bodies.

Triethyl phosphine may be prepared by the action of KHo on triethyl phosphonic iodide, $\mathrm{PEt_3HI}$, thus: $\mathrm{PEt_3HI} + \mathrm{KHo} = \mathrm{OH_2} + \mathrm{KI} + \mathrm{PEt_3}$, triethyl phosphine.

Propione is obtained by decomposing acetyl chloride by zinc ethyl.

Lactic acid. See acids.

227. The quantitative analysis of a gas suspected to contain ethylic hydride, carbonic oxide, and hydrogen gave the following results:

Volume of combustible gas, ...	32
Contraction on explosion with excess of oxygen, ...	46
Volume of CO_2 generated, ...	17

What was the percentage composition of the gas by volume?

As the volume of CO_2 generated is about half of the volume of the gas, we require to take 2 of H, producing no CO_2, 1 of CO, producing 1 of CO_2, and 1 of CH_4, producing 1 of CO_2, or 4 volumes, producing 2 of CO_2. Then $2 + 1 + 1 = 4$ or $16+8+8 = 32$.

Vol. of combustible gas.	Vol. of O consumed.	Decrease of vol. after explosion.	Vol. of CO_2 produced.
$H = 16$	8	24	0
$CO = 8$	4	4	8
$CH_4 = 8$	16	16	8
32	28	44	16

$C_2 = 24$ 46 : 24 :: 100 : 52·17 = percentage of C
$H_6 = 6$ 46 : 6 :: 100 : 13·04 = percentage of H
$O = 16$ 46 · 16 :: 100 : 34·79 = percentage of O
—
46

228. How would you quantitatively analyze a gaseous mixture consisting of marsh-gas, hydrogen, nitrogen, and carbonic oxide?

Explode a known volume with an excess of oxygen, and determine the diminution of volume produced and the volume of CO_2. Nitrogen with an excess of oxygen remains after absorption of CO_2 by solution of potash, and the amount of nitrogen is obtained by subtracting the volume of oxygen by explosion with hydrogen.

To determine the respective volume of the gases we take G, the volume of the gases taken, and CG, the volume of combustible gases, which is determined by deducting from G the amount of nitrogen, the volume of CO_2 produced by explosion call V, and the contraction of volume on explosion call CV. On exploding one volume of CO the contraction is ·5, hydrogen with excess of oxygen 1·5, marsh-gas 2·0.

The volume of hydrogen is $= CG - V = h$.

The volume of nitrogen is $= G - CG = n$.

Let C represent carbonic oxide and m marsh-gas, then $V = C + m$ and $CV = \frac{3h}{2} + \frac{C}{2} + 2m$, then we have $C = \frac{3CG - 2CV + V}{3}$ and $m = \frac{2V - 3CG + 2CV}{3}$.

With methyl, ethyl, or olefiant gas, all of which are combustible gases, we can determine their amount in the same way as above, knowing that 1 volume of any of these gases requires respectively 3·5, 6·5, and 3 volumes of oxygen for combustion, and the decrease of volume after explosion 2·5, 3·5, and 2, and the volume of carbonic anhydride produced is 2·4 and 2 respectively.

229. Name the chief constituents of crude coal-gas; state which of them are removed by the process of lime purification, and which by the substitution of ferric hydrate for lime. Mention also the constituents of purified gas to which the luminosity of a gas flame is principally due. Two samples of coal-gas yielded the following results on analysis; to which of them would you give the preference, stating your reasons?

	No. 1.	No. 2.
Hydrocarbons other than marsh-gas,...	10·56	7·48
Marsh-gas,..........	63·51	50·43
Hydrogen,..................................	19·41	35·39
Carbonic oxide,..........................	5·32	6·70
Carbonic anhydride,.....................	1·20	0·00
	100·00	100·00

One volume of the hydrocarbons other than marsh-gas in No. 1 generated 2 volumes of carbonic anhydride on combustion, whilst 1 volume of these hydrocarbons in No. 2 generated 4 volumes of carbonic anhydride. As the illuminating power of coal-gas is due to the presence of marsh-gas and other hydrocarbons, including olefiant gas, No. 1 is superior in both respects, and it is also superior to No. 2, since it contains less hydrogen and carbonic oxide, which do not produce any illuminating power, but actually reduce it. And No. 1 is superior as its hydrocarbons other than CH_4 generate only 2 volumes of CO_2, while those of No. 2 generate 4 volumes. No. 1 probably contains olefiant gas, while No. 2 contains perhaps butylene instead.

See the manufacture of coal-gas.

230. What do you understand by the terms "normal alcohol," "secondary alcohol," and "tertiary alcohol?" Give the graphic formula of a member of each class.

If we take the monohydric alcohols—

The normal alcohols may be represented in general terms by $\left\{ \begin{array}{l} C(C_aH_{2a+1})H_2 \\ CH_2Ho \end{array} \right.$.

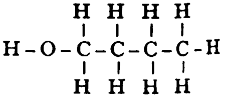
The secondary by $\left\{ \begin{array}{l} C(C_aH_{2a+1})H_2 \\ C(C_bH_{2b+1})HHo \end{array} \right.$.

The tertiary by $\left\{ \begin{array}{l} C(C_aH_{2a+1})H_2 \\ C(C_bH_{2b+1})_2Ho \end{array} \right.$.

In the formula for normal, secondary, or tertiary alcohols *a* may = 0, but in the secondary and tertiary *b* must be unity or some multiple of it. It will be observed that the compound radical C_bH_{2b+1} supplants one atom of hydrogen, forming the secondary alcohol, and supplants 2 atoms of the hydrogen of the normal alcohol, forming the tertiary alcohol.

Ethylic alcohol, a normal alcohol, has been given previously, and so has isopropylic alcohol, a secondary alcohol.

Pseudobutylic alcohol, a tertiary CMe_3Ho,



$$\begin{array}{ccccccccccccc} &&&&H&&H&&H&&H&& \\ &&&&|&&|&&|&&|&& \\ H&-&O&-&C&-&C&-&C&-&C&-&H \\ &&&&|&&|&&|&&|&& \\ &&&&H&&H&&H&&H&& \end{array}$$

231. Give the formulæ of the following acids, and mention in each case the hydricity and basicity of the acid: Butyric acid, citric acid, crotonic acid, glyoxylic acid, leucic acid, malonic acid, pyruvic acid, and tartaric acid.

Butyric acid, $\left\{\begin{matrix}C(C_2H_5)H_2\\COHo\end{matrix}\right.$, is monohydric and monobasic.

Citric acid, $\left\{\begin{matrix}CHHo(COHo)\\CH_2(COHo)\\CH(COHo)\end{matrix}\right.$, is tetrahydric and tribasic.

Crotonic acid, $\left\{\begin{matrix}C(C_2H_4)''H\\COHo\end{matrix}\right.$, is monohydric and monobasic.

Glyoxylic acid, $\left\{\begin{matrix}CHH_2O_2\\COHo\end{matrix}\right.$, is tetrahydric and monobasic.

Leucic acid, $\left\{\begin{matrix}C(C_4H_9)HHo\\COHo\end{matrix}\right.$, is dihydric and monobasic.

Malonic acid, $\left\{\begin{matrix}COHo\\CH_2\\COHo\end{matrix}\right.$, is dihydric and dibasic.

Pyruvic acid, $\left\{\begin{matrix}COMe\\COHo\end{matrix}\right.$, is monohydric and monobasic.

Tartaric acid, $\left\{\begin{matrix}COHo\\CHHo\\CHHo\\COHo\end{matrix}\right.$, is tetrahydric and dibasic.

232. Describe exactly how you would make a quantitative analysis of a sample of coal-gas.

See answer given above.

233. How would you conduct the quantitative analysis of an organic compound containing carbon, hydrogen, nitrogen, and boron?

See analysis.

234. What is the result of acting on indigo with nitric acid? How can you prepare aniline from indigo?

When boiled with fuming HNO_3 diluted with ten parts of water indigotic acid is formed, and by a longer action carbazotic acid is produced. Dilute nitric acid also converts indigo into isatin.

See aniline.

235. Define the terms "isomeric," "metameric," and "polymeric." Illustrate your reply by examples.

Bodies having the same composition but different physical or chemical properties are said to be *isomeric.*

In the fumaric series of acids there are three isomeric acids, fumaric, maleic, and isomaleic, having the general formula $C_2H_2(COHo)_2$, and itaconic acid, mesaconic, and citraconic, having the formula $C_3H_4(COHo)_2$, are isomeric.

Bodies having the same molecular weight and composition, but differing in the products yielded when acted on by chemical reagents, are termed *metameric.*

Methylic acetate, ethylic formiate, and propionic acid are metamerides.

Bodies having different molecular weights, but containing the same elements united in the same proportion, are *polymeric.*

The olefiant series C_2H_4, C_3H_6, &c., are multiples of CH_2.

236. How can the synthesis of succinic acid from its elements be accomplished? Illustrate each stage in the process by an equation.

See the preparation of ethylic alcohol from C_2H_2 generated by the electric current in an atmosphere of H between two carbon points. The alcohol can be converted into potassic propionate, which can be converted into potassic butyrate, from which butyric acid can be formed, which when oxidized yields succinic acid.

The reactions have been given above.

237. What are the names and constitutional formulæ of the known isomers of propione?

Ethylated acetone, $\left\{\begin{matrix}CEtH_2\\COMe\end{matrix}\right.$, and dimethylated acetone, $\left\{\begin{matrix}CMe_2H\\COMe\end{matrix}\right.$.

238. Given an acid of the formula $C_nH_{2n}O_2$, how would you prepare from it the corresponding alcohol, aldehyde, ketone, amine, and amide?

By distilling the potassic salt of the acid with potassic formiate we obtain the corresponding aldehyde, which by treatment with nascent hydrogen is converted into the alcohol. By distilling the potassic salt of the fatty acid we obtain the ketone. By the action of KHo on the compound formed by the action of the iodide of the corresponding radical on ammonia we obtain the amines, and the amide is obtained by distilling the ammonic salt of the acid.

239. Give the constitutional formula (both symbolic and graphic) of acetic acid, and state clearly the experimental data upon which this formula is found.

A similar question has been answered.

240. State exactly the operations required for the quantitative analysis of a gaseous mixture consisting of hydrogen, marsh-gas, carbonic oxide, carbonic anhydride, and oxygen. Give the formulæ required for the calculation of results.

A similar question has been answered.

241. You have given you the following ingredients from which to make mercuric ethide and zinc ethide:—Mercury, zinc, ethylic alcohol, iodine, ethylic acetate, sodium, and phosphorus.

Describe the necessary operations, illustrate the chemical changes by equations, and mention the most important properties of mercuric ethide and zincic ethide.

See the preparation of ethylic iodide from ethylic alcohol, iodine, and phosphorus. No perceptible action takes place when ethylic alcohol is placed in contact with sodium amalgam, but when ethylic acetate is added the amalgam is immediately attacked, gas being evolved, and the temperature rises. Ethylic iodide and one-tenth of its weight of ethylic acetate are poured on the sodium amalgam in a flask, which is agitated to promote the reaction and plunged in cold water to moderate the rise in temperature alternately. Attached to the neck of the flask is a small Liebig's condenser to arrest the ethylic iodide vapour. A subsidence of temperature and an almost total absence of precipitated iodine after a few drops of the liquid remaining in the flask is boiled with HNO_3. When a pasty condition has been produced by an excess of NaI it is well to distil off the more volatile portion by placing the flask in a water-bath and react with fresh amalgam. The residüe in the flask on the termination of the operation is distilled in an oil-bath under a temperature of 110° C. The product separates into two layers of sodic iodide and the ethereal liquid when mixed with water. Ethylic acetate is removed by alcoholic potash, and the result is washed with water, dried by calcic chloride, and rectified as $HgEt_2$, thus: $2EtI + Hg + Na = 2NaI + HgEt_2$.

See the preparation of zinc ethide from granulated zinc and ethylic alcohol.

Also see the properties of $HgEt_2$ and $ZnEt_2$.

242. Describe the preparation of ethylenic oxide from ethylic alcohol.

When 4 parts of H_2SO_4 are mixed with one of ethylic alcohol, and when cold poured into a flask and heated in a sand-bath, C_2H_4 is evolved, and when this gas is agitated with bromine and OH_2 ethylenic bromide is produced. When this bromide is treated with argentic acetate ethylenic diacetate is formed, and when this is acted on by KHo glycol is formed by the reactions already given. Glycol and HCl give ethylenic chlorhydrate: $\begin{matrix}CH_2Ho\\CH_2Ho\end{matrix} + HCl = OH_2 + \begin{matrix}CH_2Ho\\CH_2Cl\end{matrix}$, and $\begin{matrix}CH_2Ho\\CH_2Cl\end{matrix} + KHo = KCl + OH_2 + \begin{matrix}CH_2\\CH_2\end{matrix}O$, ethylenic oxide.

243. I agitate acetylene with concentrated sulphuric id, what is produced? I treat it with bromine, what is rmed? I act upon it with potassic permanganate, what emical changes take place?

With H_2SO_4 it forms vinyl sulphuric acid: $C_2H_2 + H_2SO_4 = H(C_2H_3)SO_4$.

With bromine it forms acetylenic dibromide: $C_2H_2 + Br_2 = C_2H_2Br_2$.

. With potassic permanganate oxalic acid is produced: $C_2H_2 + 4O = (COHo)_2$.

244. Describe the preparation of methyl phosphine, methyl phosphine, and trimethyl phosphine.

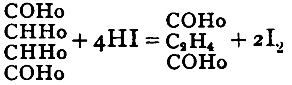
By acting on phosphonic iodide, $2PH_4I$, by methylic iodide and zincic oxide, ethyl phosphonic iodide and diethyl-phosphonic zincic iodide are produced simultaneously, thus:

$$2MeI + ZnO + 2PH_4I = OH_2 + ZnI_2 + 2PMeH_3I$$
$$4MeI + 3ZnO + 2PH_4I = 3OH_2 + ZnI_2 + 2PMe_2HZnI_2.$$

Water separates $PMeH_2$, methyl phosphine, from the mixed products, and KHo will separate PMe_2H, dimethyl phosphine. Potassic hydrate yields trimethyl when acting on trimethyl phosphonic iodide: $PMe_3HI + KHo = OH_2 + KI + PMe_3$, trimethyl phosphine.

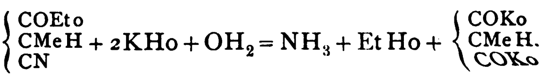
245. What acid is obtained by the action of hydriodic id upon tartaric acid, and how does the acid so obtained iffer from that which is formed by boiling ethylic cyano-ropionate with solution of caustic potash?

Succinic acid is formed:



$$\begin{matrix}COHo\\CHHo\\CHHo\\COHo\end{matrix} + 4HI = \begin{matrix}COHo\\C_2H_4\\COHo\end{matrix} + 2I_2 + 2OH_2.$$

In the second case isosuccinic acid is formed, thus:



$$\left\{\begin{matrix}COEto\\CMeH\\CN\end{matrix}\right. + 2KHo + OH_2 = NH_3 + EtHo + \left\{\begin{matrix}COKo\\CMeH.\\COKo\end{matrix}\right.$$

246. What changes take place when cinnamic acid (C_8H_7COHo) is added to fused potassic hydrate?

Potassic benzoate and acetate are formed.

247. You are in possession of the following materials, and are required to prepare normal butyric acid. How will you do it?—Ethylic acetate, iodine, water, phosphorus, sodium, and quicklime.

With sodium and water form sodic hydrate. Ethylic acetate and NaHo form alcohol and sodic acetate. See ethylic iodide for its preparation from EtHo, P, and I. By the action of sodium on ethylic acetate monosodacetic ether is formed, thus: $2\left\{\begin{matrix}CH_3\\COEto\end{matrix}\right. + Na_2 = 2\left\{\begin{matrix}CHNa\\COEto\end{matrix}\right. + H_2$. And $\left\{\begin{matrix}CHNa\\COEto\end{matrix}\right. + EtI = NaI + \left\{\begin{matrix}C_3H_7\\COEto\end{matrix}\right.$.

248. Describe the preparation of artificial alizarine. Give equations.

Anthracene, $C_{14}H_{10}$, when oxidized, gives $C_{14}H_8O_2$, anthraquinone, which heated strongly with H_2SO_4 yields disulphanthraquinonic acid, $C_{12}H_6(COHoSO_2)_2$, that gives, when heated with KHo, potassic alizarate, thus: $C_{12}H_6(SO_2COHo)_2 + 6KHo = 4OH_2 + 2K_2SO_4 + C_{12}H_6(COKo)_2$, potassic alizarate, and $C_{12}H_6(COKo)_2 + 2HCl = 2KCl + C_{12}H_6(COHo)_2$, alizaric acid, or alizarine.

249. What effect is produced by heating citric acid with hydriodic acid?

Tricarballylic acid is formed, thus:

$$\begin{matrix}CHHo(COHo)\\CH_2(COHo)\\CH(COHo)\end{matrix} + 2HI = I_2 + OH_2 + \left\{\begin{matrix}CH_2(COHo)\\CH(COHo)\\CH_2(COHo)\end{matrix}\right. .$$

250. In the quantitative analysis of a hydrocarbon gas 1 volume was mixed with 10 volumes of oxygen and exploded in a eudiometer. After the explosion 8·5 volumes remained. On examining the residual gas it was found to contain 2 volumes of carbonic anhydride.

What was the molecular composition of the inflammable gas?

Oxygen. Hydrocarbon gas.
10 vols. + 1 vol. = 11 vols. of mixture.
11 vols. – 8·5 vols. = 2·5 = decrease of volume.
8·5 vols. – 2 vols. of CO_2 = 6·5 = excess of oxygen.
10 vols. – 6·5 vols. = 3·5 vols. of oxygen consumed.

As methyl, $(CH_3)_2$, or C_2H_5H, ethyl hydride, requires 3.5 volumes of oxygen to explode 1 volume, producing a decrease of 2·5 volumes, and yielding 2 volumes of CO_2, it follows that $(CH_3)_2$ or C_2H_5H must be the molecular composition of the gas.

251. Starting with the elements carbon, hydrogen, oxygen, and nitrogen, and having also at your command caustic potash, sulphuric acid, zinc, lead, red potassic chromate, iodine, and phosphorus, describe how you would produce the following organic compounds:—Ethylene, ethylic alcohol, propionic acid, butyric acid, isopropylic alcohol, benzol, naphthaline, diethylamine, and zinc ethyl.

As already repeatedly stated we can produce C_2H_2, acetylene, by passing a current between carbon points in an atmosphere of hydrogen, and nascent hydrogen converts this into C_2H_4, ethylene, thus: $C_2H_2 + H_2 = C_2H_4$. Sulphuric acid converts C_2H_4 into $HEtSO_4$, sulphovinic acid, and OH_2 converts this into alcohol, thus: $HEtSO_4 + OH_2 = H_2SO_4 + EtHo$, ethylic alcohol.

From the materials we can prepare potassium carbonate, and by heating it with C to a bright-red heat in a current of nitrogen, potassium cyanide is produced.

Then $HEtSO_4 + KCN = KHSO_4 + \left\{\begin{matrix}C_2H_5\\CN\end{matrix}\right.$, ethylic nitrile, and $\left\{\begin{matrix}C_2H_5\\CN\end{matrix}\right. + KHo + OH_2 = NH_3 + \left\{\begin{matrix}C_2H_5\\COKo\end{matrix}\right.$, potassic propionate.

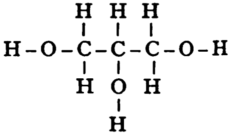
Then, starting with potassic propionate and potassic formiate, which can be prepared from acetylene, oxygen, and KHo, we can, by a series of reactions given previously, obtain potassic butyrate.

By passing the vapour of acetic acid through a porcelain tube heated to redness we obtain acetone, $\left\{\begin{matrix}CH_3\\COMe\end{matrix}\right.$, and nascent hydrogen acting on this produces $\left\{\begin{matrix}CH_3\\CMeHHo\end{matrix}\right.$, isopropylic alcohol.

Benzol, C_6H_6, is produced when the vapour of alcohol or acetic acid is passed through red-hot tubes. Naphthalin, $C_{10}H_8$, is produced when C_2H_4, olefiant gas, or ethylene, is passed through red-hot tubes. With the NH_3, ammonia, produced in the above reaction and EtI we obtain $NEtH_3I$, ethylammonic iodide, and this with KHo forms $OH_2 + KI + NEtH_2$, ethylamine, and this latter $+ EtI = NEt_2H_2I$, which with KHo gives $OH_2 + KI + NEt_2H$, diethylamine. And when zinc and EtI are heated together in a closed vessel to 100° C. $ZnEt_2$ is produced.

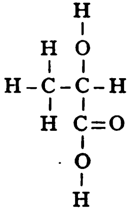
252. How can you obtain glycerine from tallow, and what are the rational, constitutional, and graphic formulæ of glycerine?

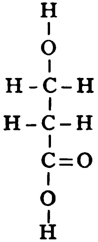
Tallow, $\left\{\begin{matrix}CH_2 - O - C(C_{17}H_{35})O\\CH\ - O - C(C_{17}H_{35})O\\CH_2 - O - C(C_{17}H_{35})O\end{matrix}\right.$, when heated to a high temperature with water, $3OH_2$, forms stearic acid, $3\left\{\begin{matrix}C_{17}H_{35}\\COHo\end{matrix}\right. + CHHo(CH_2Ho)_2$, glycerine.

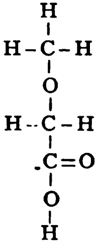
Rational Formula.	Constitutional Formula.	Graphic Formula.
$C_3H_5H_3O_3$	$\left\{\begin{matrix}CH_2Ho\\CHHo\\CH_2Ho\end{matrix}\right.$	 $\begin{array}{ccccccccccccc} & & & & H & & H & & H & & & & \\ & & & & \vert & & \vert & & \vert & & & & \\ H & - & O & - & C & - & C & - & C & - & O & - & H \\ & & & & \vert & & \vert & & \vert & & & & \\ & & & & H & & O & & H & & & & \\ & & & & & & \vert & & & & & & \\ & & & & & & H & & & & & & \end{array}$

253. Give some instances of isomerism in the lactic and acrylic series of acids, illustrating the causes of isomerism by graphic formulæ.

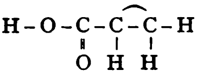
Lactic acid is expressed symbolically by $\left\{\begin{matrix}CMeHHo\\COHo\end{matrix}\right.$, paralactic acid by $\left\{\begin{matrix}CH_2Ho\\CH_2(COHo)\end{matrix}\right.$, and methyl glycollic by $\left\{\begin{matrix}CH_2Meo\\COHo\end{matrix}\right.$, and they are respectively graphically written:

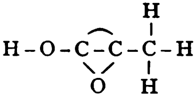


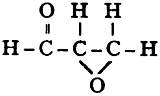




In the acrylic series we have acrylic acid, $\left\{\begin{matrix}C(CH_2)''H\\COHo\end{matrix}\right.$, and $\left\{\begin{matrix}CCH_3\\COHo\end{matrix}\right.$, and $\left\{\begin{matrix}C_2H_3\\COHo\end{matrix}\right.$, and graphic formulæ as,







254. I add alcoholic solution of potash to a mixture of ethylamine and chloroform,—what occurs? I boil the ethereal product of this operation with hydrochloric acid, —what takes place?

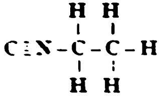
$NEtH_2 + CH_2Cl_3 = 3HCl + EtCN$, the normal cyanide, and $EtCN + HCl + 2OH_2 = HCOHo + EtNH_3Cl$, the hydrochlorate of ethylamine.

255. What ethereal product is obtained by the distillation of a mixture of potassic sulphovinate and potassic cyanide, and what change takes place when this product is boiled with hydrochloric acid? Explain by graphic formulæ the relations of this ethereal product to the one obtained by the process mentioned in the preceding question.

$KEtSO_4$, potassic sulphovinate, $+ KCN = K_2SO_4 + EtCN$, the abnormal cyanide.

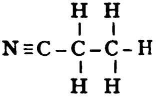
$$EtCN + HCl + 2OH_2 = NH_4Cl + EtCOHo.$$

Normal Cyanide.



$$C \equiv N - \underset{H}{\overset{H}{C}} - \underset{H}{\overset{H}{C}} - H$$

Abnormal Cyanide.



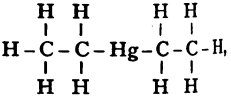
$$N \equiv C - \underset{H}{\overset{H}{C}} - \underset{H}{\overset{H}{C}} - H$$

256. How do you distinguish organo-metallic bodies from ordinary organic compounds containing metals? Describe the preparation of mercuric ethide, and state what occurs when this body is placed in contact with the following metals:—Zinc, silver, aluminium, and platinum.

For the preparation of $HgEt_2$, see answer to previous question.

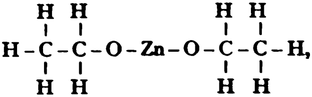
For the organo-metallic bodies the organic radical is directly united with the metal, but in ordinary organic compounds the organic radical and metal are indirectly united, thus:

In mercuric ethide, $HgEt_2$,



$$H - \underset{H}{\overset{H}{C}} - \underset{H}{\overset{H}{C}} - Hg - \underset{H}{\overset{H}{C}} - \underset{H}{\overset{H}{C}} - H,$$

the metal Hg and the radical C_2H_5 are united directly, but in zinc ethylate, $ZnEt_2O_2$,



$$H - \underset{H}{\overset{H}{C}} - \underset{H}{\overset{H}{C}} - O - Zn - O - \underset{H}{\overset{H}{C}} - \underset{H}{\overset{H}{C}} - H,$$

the zinc is united indirectly to the radical C_2H_5 by means of oxygen, as shown in the graphic formula.

More positive metals displace Hg thus:

$$HgEt_2 + Zn = ZnEt_2 + Hg$$
$$3HgEt_2 + Al_2 = Al_2Et_6 + 3Hg.$$

257. How can toluylic acid be obtained from toluidine?

Toluidine, $(C_7H_7)NH_2 + (COHo)_2$, by distillation $= CO_2 + OH_2 + NH(C_7H_7)COH$, tolylformamide, which heated becomes $OH_2 + \left\{\begin{matrix} C_7H_7 \\ CN \end{matrix}\right.$, tolyl nitrile.

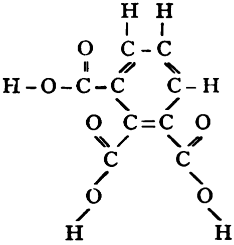
and this when heated with KHo yields a potassic salt of toluylic acid, thus:

$$\left\{\begin{matrix}C_7H_7\\CN\end{matrix}\right. + KHo + OH_2 = NH_3 + \left\{\begin{matrix}C_7H_7\\COKo\end{matrix}\right..$$

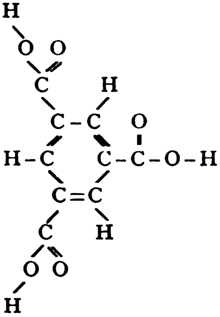
258. Illustrate by graphic formulæ the probable cause isomerism in the following compounds:—

$$\left.\begin{matrix}\text{Trimellitic acid}\\\text{Trimesic acid}\\\text{Hemimellitic acid}\end{matrix}\right\} C_9H_6O_6.$$

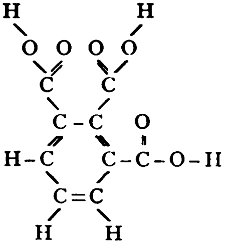
Trimellitic Acid.



Trimesic Acid.



Hemimellitic Acid.



259. Explain the action of hydriodic acid upon eryth- e, and that of nascent hydrogen upon glucose.

Erythrite, $(CH_2Ho)_2(CHHo)_2 + 7HI = 3I_2 + 4OH_2 + C_4HgI$, butylic iodide.

Glucose, $2(CH_2Ho, CHHo, CHo) + H_2 = 2\{CH_2Ho(CHHo)_2\}$, mannite.

260. Describe the preparation of normal ethylic cyanide and abnormal ethylic cyanide. Give the graphic formula of each, and give the reactions by which these cyanides are distinguished from each other.

See the answer given above.

261. Describe minutely how you would analyse a gaseous mixture containing the following compounds:—Hydrochloric acid, ethylic hydride, ethyl, oxygen, carbonic anhydride, and nitrogen. Show the method of calculating the composition of the gas from the experimental numbers.

See answer to previous questions.

262. What products are formed when the following compounds are boiled with aqueous solution of caustic soda? Give equations.

(1) Ethylic ethaceto-acetate, $\left\{\begin{array}{l} COMe \\ CHEt \\ COEto \end{array}\right.$.

(2) Cyanhydric glycol, $\left\{\begin{array}{l} CH_2Ho \\ CH_2CN \end{array}\right.$.

(3) Ethylic α cyanopropionate, $\left\{\begin{array}{l} CN \\ CMeH \\ COEto \end{array}\right.$.

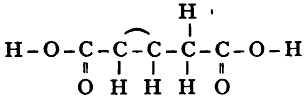
No. 1 when acted on gives $CONa_2O_2 + EtHo + \left\{\begin{array}{l} COMe \\ CH_2Et \end{array}\right.$, ethylated acetone.

No. 2 gives NH_3 and $\left\{\begin{array}{l} CH_2Ho \\ CH_2(CoNao) \end{array}\right.$, sodic paralactate.

No. 3 gives NH_3 and $EtHo$ and $\left\{\begin{array}{l} CONao \\ CMeH \\ CONao \end{array}\right.$, sodic isosuccinate.

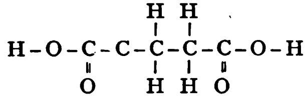
263. Illustrate by graphic formulæ the probable cause of isomerism in the following acids:—Itaconic acid, citraconic acid, and mesaconic acid.

It is impossible at present to determine out of the fourteen possible formulæ for this five carbon group of acids the correct ones, but three may be given by way of illustration.



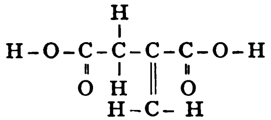
$$\mathrm{H-O-\underset{\overset{\|}{O}}{C}-\underset{\overset{|}{H}}{C}\overset{\frown}{-}\underset{\overset{|}{H}}{C}-\underset{\overset{|}{H}}{\overset{\overset{H}{|}}{C}}-\underset{\overset{\|}{O}}{C}-O-H}$$

$\{(COHo)_2(CH)_2CH_2\}$.



$$\mathrm{H-O-\underset{\overset{\|}{O}}{C}-C-\underset{\overset{|}{H}}{\overset{\overset{H}{|}}{C}}-\underset{\overset{|}{H}}{\overset{\overset{H}{|}}{C}}-\underset{\overset{\|}{O}}{C}-O-H}$$

$\{C(CH_2)_2(COHo)_2\}$.



$$\mathrm{H-O-\underset{\overset{\|}{O}}{C}-\underset{\overset{|}{H}}{\overset{\overset{H}{|}}{C}}-\underset{\underset{H-C-H}{\|}}{C}-\underset{\overset{\|}{O}}{C}-O-H}$$

$\{CMe''CH_2(COHo)_2\}$.

264. Describe the preparation and properties of ammonia-boric methide, beginning with boric ethylate. What is the weight in criths of 1 litre of the vapour of this compound?

Boric ethylate, $2BEt_3O_3 + 3ZnMe_2 = 3ZnEt_2O_2 + 2BMe_3$.

Boric methide, $BMe_3 + NH_3 = BMe_3NH_3$ ammonia-boric methide.

$$\begin{array}{r} 3(CH_3) = 45 \\ B = 11 \\ \hline 2\,)\,56 \\ \hline 28 \text{ criths.} \end{array}$$

265. A silver salt of an organic monobasic acid gave the following analytical results:—(1) 0·2065 substance gave 0·2025 CO_2 and 0·076 H_2O. (2) 0·259 substance gave 0·12475 Ag. Required the formula and molecular weight of the acid.

$${\cdot}2025 \times 3 \div 11 = {\cdot}0552 = C, \text{ and } {\cdot}076 \div 9 = {\cdot}0084 = H.$$

$${\cdot}259 : {\cdot}2025 :: {\cdot}12475 : {\cdot}09754 = Ag.$$

$$\begin{array}{r@{\,=\,}l} C & {\cdot}0552 \\ H & {\cdot}0084 \\ Ag & \underline{{\cdot}09754} \end{array}$$

$${\cdot}2065 - {\cdot}16114 = {\cdot}04536 = O.$$

$$\left.\begin{array}{l} {\cdot}2065 : {\cdot}0552 :: 100 : 26{\cdot}75 = C \div 12 = 2{\cdot}23 \div {\cdot}44 = 5 \\ {\cdot}2065 : {\cdot}0084 :: 100 : 4{\cdot}07 = H \div 1 = 4{\cdot}07 \div {\cdot}44 = 9 \\ {\cdot}2065 : {\cdot}04536 :: 100 : 21{\cdot}96 = O \div 16 = 1{\cdot}37 \div {\cdot}44 = 3 \\ {\cdot}2065 : {\cdot}09754 :: 100 : 47{\cdot}23 = Ag \div 108 = {\cdot}44 \div {\cdot}44 = 1 \end{array}\right\} \begin{array}{l} C_5H_9 \\ O_3Ag. \end{array}$$

$\left\{\begin{array}{l} C_4H_9O \\ COAgO \end{array}\right. = \begin{array}{l} C(C_3H_7)HHo \\ COHo \end{array}$ acid, and molecular weight $= 225$.

266. State the relation of the following bodies to benzene, and describe their preparation from this compound: aniline, phenol, benzoic acid, and benzoic aldehyde.

These compounds all contain the radical C_6H_5, and the acid is prepared from the alcohol by oxidation.

See the preparation of aniline, carbolic acid, or phenylic alcohol, and benzoic aldehyde.

267. Explain the production of aconitic acid from citric acid, and the change which aconitic acid suffers when it is heated to 160° C.

Citric acid, $C_3H_5O(COHo)_3 + HBr = OH_2 + C_3H_4Br(COHo)_3 = HBr + C_3H_3(COHo)_3$, aconitic acid. When the latter is heated it is converted into itaconic acid, thus: $C_3H_3(COHo)_3 = CO_2 + C_3H_4(COHo)_2$.

268. Describe minutely the mode of preparation and properties of artificial alizarin, mercuric methide, and cacodylic acid.

See the preparation of alizarin and mercuric methide elsewhere.

Cacodyl, As_2Me_4, absorbs oxygen, becoming As_2Me_4O, which absorbs oxygen and water from the moist atmosphere: $As_2Me_4O + OH_2 + O_2 = 2AsMe_2OHo$.

Alizarine is a crystalline red substance without taste or odour. When heated to about 215° C. it is sublimed in anhydrous lustrous transparent orange needles, and a part of it is decomposed. It is soluble in ether, less soluble in alcohol, and sparingly soluble in hot water.

Potash dissolves alizarin, producing a purple colour. The oxides of iron, barium, and calcium form insoluble purple lakes. When boiled with dilute nitric acid phthalic acid is formed.

See mercuric ethide for properties.

Cacodylic acid crystallizes in oblique equilateral prisms. The silver salt crystallizes best. It has little or no poisonous action on animals. Water and alcohol dissolve it. It decomposes carbonates very slowly.

269. Discuss the experimental evidence for and against the proposition that the monad alcohol radicals and the corresponding paraffins are severally identical.

See methyl and ethyl hydride.

270. What compounds are formed when benzylic chloride (chlortoluol) is digested with plumbic nitrate and water? Give an equation.

Benzoic aldehyde is formed, thus: $2C_7H_7Cl + N_2O_4 Pbo'' = OH_2 + N_2O_3 + PbCl_2 + 2C_6H_5COH$.

271. Describe verbally and by graphic formulæ the probable cause of isomerism in (1) lactic acid, paralactic acid, hydracrylic acid, and methyl-glycolic acid. (2) Trimellitic acid, trimesic acid, and hemimellitic acid.

See answer to other questions.

272. How would you prepare active and inactive malic acid from active and inactive aspartic acid? Give equations.

Aspartic acid, active or inactive, when dissolved in HNO_3 and saturated with N_2O_3, yields active or inactive malic acid, thus: $2CMeNH_2(COHo)_2 + N_2O_3 = OH_2 + 2N_2 + 2CMeHo(COHo)_2$.

273. Describe the mode of determining the density of a vapour by Gay-Lussac's and by Dumas' process. In the determination of a vapour density by the former process the following data were obtained:—

Weight of substance, ...	·1163 grm.
Observed volume of vapour, ...	50·77 cubic centimetres.
Temperature of bath, ...	215° C.
Height of barometer, ...	755·5 millimetres.
Difference of height of mercury inside and outside of tube,...	80·0 ,,
Height of spermaceti or oil column reduced to millimetres of mercury,...........	16·9 ,,

Required the specific gravity of the vapour, the density of hydrogen being taken as unity, also the weight of 1 litre at 0° C. and 760 mm. barometrical pressure.

$$16{\cdot}9+775{\cdot}5-80{\cdot}0=692{\cdot}4$$

$$50{\cdot}77\times\frac{692{\cdot}4\times273}{760\times488}=25{\cdot}9$$

1 centimetre of air weighs ·0012936 grm., ∴ 25·9 will weigh 25·9 × ·0012936 = ·03350424 grm. And ·1163 ÷ ·0335 = 3·47, which, multiplied by 14·47, gives 50·2149 as the specific gravity of the vapour. Since 25·9 weighs ·1163 grm. 1000 will weigh 4·5 grm.

Gay-Lussac's and Dumas' processes have been already described.

274. Explain fully what is meant by isomerism, metamerism, and polymerism in organic bodies.

Isomeric bodies are those having the same percentage composition.

Metameric bodies have the same molecular weight and the same percentage composition.

Polymeric bodies have different molecular weights but the same percentage composition.

Considering the number of elements that enter into the composition of organic compounds are so few, and that the varieties of qualities are so great, they cannot be due to the contained radicals alone, but must be influenced in a great measure by the molecular arrangement of these radicals, and a transference of CH_2 or nCH_2 from the alcohol to the acid radical, and *vice versa.*

The oxide of ethylene $(C_2H_4)''O$, aldehyde CH_3COH, ethylic acetate CH_3COEto, and butyric acid C_3H_7COHo, are isomeric bodies.

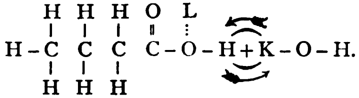
The latter two are metameric, and so are the two first substances, but aldehyde and butyric acid are polymeric.

Butyric acid and ethylic acetate are wholly different in their qualities, although they contain the same amount of carbon, hydrogen, and oxygen, and have the same specific gravity and molecular weight.

Butyric acid, smelling like rancid butter, is an oily liquid that causes alkaline carbonates to effervesce, reddens litmus paper, and boils at 150° C., while acetic ether is a limpid liquid, having an agreeable odour, somewhat like that of apples, and boils at 74° C.

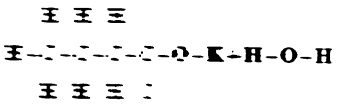
Acetic acid has the formula CH_3COHo, potassic acetate CH_3COKo, and ethylic acetate will have the formula $CH_3CO(C_2H_5)o$. By acting on $CH_3CO(C_2H_5)o$ by KHo we obtain CH_3COKo and C_2H_5Ho, but when we act on butyric acid C_3H_7COHo by KHo we obtain C_3H_7COKo and OH_2. From this reaction we conclude that the K in KHo displaces merely the H in the group COHo or the radical, such as C_2H_5, which takes the place of the H, and that the radicals CH_3 and C_3H_7 are unaffected in either case. The reaction, perhaps, might be made plainer by means of graphic formulæ.

Butyric acid,



$$\begin{array}{cccccl} & H & H & H & O & L \\ & | & | & | & \| & \vdots \\ H- & C & C & C & C & -O-H+K-O-H. \\ & | & | & | & & \\ & H & H & H & & \end{array}$$

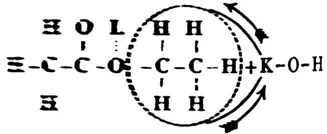
Potassic hydrate becomes, by the interchange of the elements K and H, potassic butyrate:



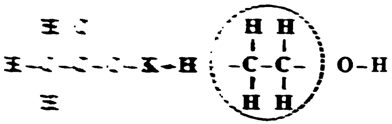
$\mathrm{H-C-C-C-C-O-K+H-O-H}$

and water.

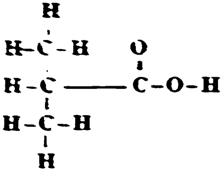
Ethylic acetate



results by the interchange of the radical C_2H_5 and K—



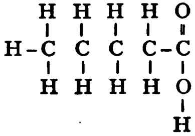
potassic acetate and ethylic or common alcohol. We observe from the reactions produced that the KHo does not break up or act on the group firmly interlocked to the left of the O, above which is placed the letter L in both cases, but on the outlying elements, H, and the radical C_2H_5 (to the right of O marked L), which are as it were loosely suspended or attached, and are therefore easily displaced by the K of the KHo, and isobutyric acid, represented graphically,



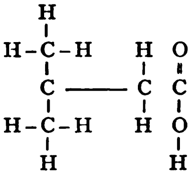
has the same composition as butyric acid and acetic ether.

The molecular structure of valeric acid can be represented in four different ways, three of which have been identified.

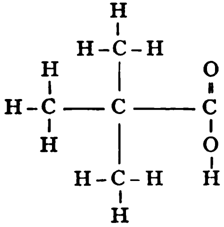
The normal acid,



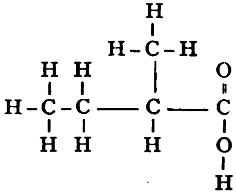
The isovaleric,



The isopropacetic and
the trimethacetic,



And the fourth metheth-
acetic acid,



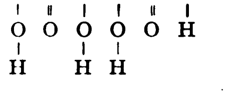
They are represented symbolically by C_4H_9COHo, $CH(CH_3)_2CH_2COHo$, CMe_3COHo, and MeEtCH COHo. The first and third are more symmetrical than the others. As in the case of butyric acid, it is the atom of hydrogen to the right in the four graphic formulæ given above that is not so thoroughly incorporated in the compound, and is therefore displaced by any radical or element capable of substituting it.

Methyl valeryl, $CH_3C_5H_9O$, and ethyl butyryl, $C_2H_5C_4H_7O$, are isomers. Trityl ethyl ether, $C_3H_7C_2H_5O$, tetryl methyl ether, $C_4H_9CH_3O$, and amylalcohol, $C_5H_{11}Ho$, are isomeric, being equal $C_5H_{12}O$.

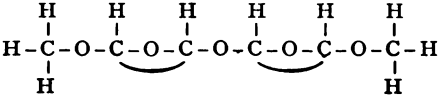
Ethylene dichloride, $(C_2H_4)''Cl_2$, and monochlorethyl chloride, C_2H_4ClCl, are isomers.

Also the following cases, viz. propylic alcohol, $C_2H_5CH_2Ho$, and isopropylic alcohol, $CH_3CH(CH_3)Ho$; lactic acid, $CHMeHoCOHo$, paralactic acid, $(CH_2)_2HoCOHo$, and methyl glycolic acid, $CH_2MeOCOHo$; the four forms of tartaric, fumaric, malic, and isomalic acids, $(CH)_2(COHo)_2$; cane-sugar and its isomers having the formula $C_{12}H_{22}O_{11}$; grape-sugar, $C_6H_{12}O_6$, and its isomers; starch, $C_6H_{10}O_5$, and its isomers. The difference in all these bodies having the same composition therefore depends on different arrangements of the atoms of carbon, hydrogen, and oxygen. For instance, starch has 6 atoms of carbon, 10 of hydrogen, and 5 of oxygen, and by different arrangements of these atoms among themselves we obtain dextrine, gum, cellulose, glycogen, &c., the isomers of starch. Supposing we placed 6 black cubes on a chess-board to represent 6 atoms of carbon, 10 blue cubes for hydrogen, and 5 white cubes for the oxygen in starch. If these cubes were arranged on the board in different positions consistent with the tetrad, monad, and diad characters of the carbon, hydrogen, and oxygen respectively, we should obtain dextrine, gum, cellulose, glycogen, &c. The following are some of the arrangements that may be made, viz.:—

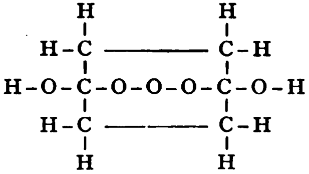
(1)



(2)



(3)



Rutic acid, methyl pelargonate, ethyl caprylate, trityl œnanthate, tetryl caproate, amyl valerate, hexyl butyrate, heptyl propionate, octyl acetate, nonyl formiate, represented by $HC_{10}H_{19}O_2$, $CH_3C_9H_{17}O_2$, $C_2H_5C_8H_{15}O_2$, $C_3H_7C_7H_{13}O_2$, $C_4H_9C_6H_{11}O_2$, $C_5H_{11}C_5H_9O_2$, $C_6H_{13}C_4H_7O_2$, $C_7H_{15}C_3H_5O_2$, $C_8H_{17}C_2H_3O_2$, $C_9H_{19}CHO_2$, all equal to $C_{10}H_{20}O_2$, are metamers, and are formed by adding nCH_2 to the alcohol-forming radical, and subtracting nCH_2 from the acid-forming radical.

Trityl trityl, ethyl tetryl, methyl amyl, and hexyl hydride, represented respectively by $C_3H_7C_3H_7$, $C_4H_9C_2H_5$, $C_5H_{11}CH_3$, $C_6H_{13}H$, are metamers.

Oxide of tritylene, $(C_3H_6)''O$, allylic alcohol, C_3H_5Ho, propylic aldehyde, C_2H_5COH, common acetone, $CO(CH_3)_2$, are metameric on oxidation, yielding lactic acid, acroleine, and acrylic acid, propionic acid, and lower fatty acids respectively.

Ethylic alcohol, C_2H_5Ho, and methyl ether, $(CH_3)_2O$, are metamers.

Triethylamine, trityl ethyl methylamine, ditritylamine, tetryl dimethylamine, tetryl ethylamine, amyl methylamine, hexylamine, represented respectively by $(C_2H_5)_3N$, $CH_3C_2H_5C_3H_7N$, $(C_3H_7)_2NH$, $C_4H_9(CH_3)_2N$, $C_4H_9C_2H_5NH$, $C_5H_{11}CH_3NH$, and $C_6H_3NH_2$, all of which give different alcohols when treated with nitrous acid and tricetylamine, $N(C_{16}H_{33})_3$, has more than 300 metamers giving different results with nitrous acid.

Glyocine, a crystalline solid, $C_2H_2NH_2OHo$, and nitrite of ethyl, $NO_2C_2H_5$, a liquid, are metamers, and so are urea, $CO(NH_2)_2$, and cyanate of ammonium, $CNNH_4O$.

The following compounds are polymers, viz.: Cyanic acid, CHNO and $C_3H_3N_3O_3$; cyanide of ethyl, C_2H_5CN, and cyanethine, $C_6H_{15}(CN)_3$; aldehyde, CH_3COH, leucic acid, $C_6H_{12}O_3$, and butyric acid, C_3H_7COHo; acetic acid, $C_2H_4O_2$, lactic acid, $C_3H_6O_3$, and grape-sugar, $C_6H_{12}O_6$; C_2H_2, acetylene, a gas, and C_6H_6, a liquid, and the olefines having the general formula C_nH_{2n}.

APPENDIX.

IST OF THE ELEMENTS, WITH THEIR SYMBOLS, ATOMICITIES, ATOMIC WEIGHTS, AND SPECIFIC GRAVITIES.

Elements.	Symbol.	Atomicity.	Atomic Weight.	Specific Gravity.
Aluminium,	Al	4	27·3	2·6
Antimony,	Sb	5	122·0	6·7
Arsenic,	As	5	75·0	5·7
Barium,	Ba	2	137·0	4·0
Bismuth,	Bi	5	210·0	8·8
Boron,	B	3	11·0	2·7
Bromine,	Br	1	79·75	2·9
Cadmium,	Cd	2	112·0	8·5
Cæsium,	Cs	1	133·0	...
Calcium,	Ca	2	39·9	1·6
Carbon,	C	4	11·97	3·5
Cerium,	Ce	6	141·2	5·5
Chlorine,	Cl	1	35·37	1·4
Chromium,	Cr	6	52·4	7·0
Cobalt,	Co	6	58·6	8·5
Copper,	Cu	2	63·0	8·9
Didymium,	D	2	147·0	...
Erbium,	E	2	169·0	...
Fluorine,	F	1	19·1	...
Glucinum,	G	2	9·0	2·1
Gold,	Au	3	196·2	19·4
Hydrogen,	H	1	1·0	1·0 (gas)
Indium,	In	2	113·4	7·4
Iodine,	I	1	126·5	4·9
Iridium,	Ir	6	196·7	21·2
Iron,	Fe	6	55·9	7·8
Lanthanum,	L	2	139·0	...
Lead,	Pb	4	206·4	11·4
Lithium,	Li	1	7·0	·6
Magnesium,	Mg	2	23·9	1·7
Manganese,	Mn	6	54·8	8·0

Elements.	Symbol.	Atomicity.	Atomic Weight.	Specific Gravity.
Mercury,	Hg	2	199·8	13·6
Molybdenum,	Mo	6	95·6	8·6
Nickel,	Ni	6	58·6	8·9
Niobium,	Nb	4	94·0	7·0
Nitrogen,	N	5	14·0	14·0 (gas)
Osmium,	Os	6	198·6	21·3
Oxygen,	O	2	16·0	16·0 (gas)
Palladium,	Pd	4	106·2	11·4
Phosphorus,	P	5	30·9	1·8
Platinum,	Pt	4	196·7	21·2
Potassium,	K	1	39·0	·86
Rhodium,	Rh	6	104·1	12·1
Rubidium,	Rb	1	85·2	1·5
Ruthenium,	Ru	6	103·5	11·2
Selenium,	Se	6	78·0	4·3
Silicon,	Si	4	28·0	2·5
Silver,	Ag	1	107·6	10·5
Sodium,	Na	1	23·0	·98
Strontium,	Sr	2	87·2	2·5
Sulphur,	S	6	32·0	2·0
Tantalum,	Ta	4	182·0	10·8
Tellurium,	Te	6	128·0	6·2
Thallium,	Tl	3	203·6	11·8
Thorium,	Th	4	231·5	7·7
Tin,	Sn	4	117·8	7·3
Titanium,	Ti	4	48·0	...
Tungsten,	W	6	184·0	17·7
Uranium,	U	6	240·0	18·4
Vanadium,	V	5	51·2	5·5
Yttrium,	Y	2	93·0	...
Zinc,	Zn	2	64·9	7·1
Zirconium,	Zr	4	90·0	4·2

METRICAL WEIGHTS AND MEASURES.

Linear Measure.

1 millimetre = ·001 metre.
1 centimetre = ·01 metre.
1 decimetre = ·1 metre.
1 metre = 39·37 inches.
1 decametre = 10 metres.
1 hectometre = 100 metres.
1 kilometre = 1000 metres.

Measure of Volume.

1 millilitre = 1 cubic centimetre, or the measure of 1 gram of water.
1 centilitre = 10 cubic centimetres.
1 decilitre = 100 cubic centimetres.
1 litre = 1000 cubic centimetres, or 1·76 pint, or 61·027 cubic inches.
1 decalitre = 10 litres.
1 hectolitre = 100 litres.
1 kilolitre = 1000 litres, or 1 cubic metre.

Weights.

1 milligram = ·001 gram.
1 centigram = ·01 gram.
1 decigram = ·1 gram.
1 gram = weight of a cubic centimetre of water at 4° C., or 15·432 grains.
1 decagram = 10 grams.
1 hectogram = 100 grams.
1 kilogram = 1000 grams.

1 litre of hydrogen at 0° C. and 760 mm. bar. weighs 1 crith or ·0896 gram.

Linear Measure.

1 inch = 2·54 centimetres.
1 foot = 3·048 decimetres.
1 yard = ·9144 metre.

Superficial Measure.

1 square inch = 6·4514 square centimetres.
1 square foot = 9·29 square decimetres.
1 square yard = ·8361 square metre.

Cubical Measure.

1 cubic inch = 16·3862 cubic centimetres.
1 cubic foot = 28·315 cubic decimetres.

Weights.

1 grain = ·0648 gram.
1 ounce = 437·5 grains.
1 pound = 7000 grains.

Measure of Capacity.

1 minim	=	·91 grain of water.
1 fluid drachm	=	60 minims, or 54·68 grains of water.
1 fluid ounce	=	8 fluid drachms, or 437·5 grains of water.
1 pint	=	20 fluid ounces, or 1·25 pound of water.
1 gallon	=	8 pints, or 10 pounds of water.

Multiply the specific gravity with reference to hydrogen by ·06926 to obtain the specific gravity compared with air.

Multiply the specific gravity with reference to air by 14·438 to obtain the specific gravity compared with hydrogen.

Multiply kilograms per square centimetre by 14·2247 to obtain pounds per square inch.

Multiply pounds per square inch by ·0703 to obtain kilograms per square centimetre.

Multiply inches by 2·54 to obtain centimetres.

Multiply centimetres by ·3937 to obtain inches.

Multiply kilograms by 2·2046 to obtain pounds.

Multiply litres by ·22 to obtain gallons.

Multiply grams by 15·432 to obtain grains.

Multiply grains by ·068 to obtain grams.

In analysis the weight of water obtained, multiplied by ·11111, gives the hydrogen.

The weight of carbonic anhydride, multiplied by ·2727 gives the amount of carbon.

To find the weight of an element in a compound having a given weight, multiply the weight (atomic) of the given element by the number of atoms of the element in the molecule, and multiply this result by the given weight and divide by the molecular weight.

From the formula of a compound the percentage composition is found by dividing the molecular weight into 100 times the weight of each of the constituents in a molecule.

To find the weight of a substance necessary to produce a given weight of a substance, multiply the molecular weight of the given substance by the number of molecules required, and this result by the given weight of the substance produced, divided by the molecular weight of the given substance, multiplied by the number of molecules. Thus, how much stearine would be required to 1 cwt. of glycerine?

$$\underset{\text{Stearine.}}{C_3H_5(COC_{17}H_{35}O)_3} + 3OH_2 = \underset{\text{Glycerine.}}{C_3H_5Ho_3} + \underset{\text{Stearic acid.}}{3C_{17}H_{35}COHo.}$$

Molecular Weight. 890 — Molecular Weight. 92

$$92 : 112 :: 890 : Q = 1083\tfrac{11}{23} \text{ lbs.}$$

To estimate the amount of nitrogen by volume,

$$W = \frac{\cdot0012562 \times V \times p}{(1 + \cdot00367t)760}.$$

In which formula p = the pressure corrected for the tension of the aqueous vapour, t = the temperature in degrees Centigrade, V = the volume of nitrogen, and W = the weight of the nitrogen.

$\frac{v}{v'} = \frac{(t + 273)}{(t' + 273)} \cdot \frac{p'}{p}$ is the formula for the correction of gases for pressure and temperature, in which p represents the original pressure, p' the final pressure, t and t' the original and final temperatures Centigrade respectively, and v and v' the original and corrected volumes.

COMBUSTIBLE GASES AND THE PRODUCTS OF EXPLOSION.

GASES.	Volume of Combustible Gas.	Volume of Oxygen Consumed.	Volume of Carbonic Anhydride Produced.	Contraction after Explosion.
Hydrogen, ...	1	0·5	0	1·5
Carbonic oxide, ...	1	0·5	1	0·5
Methyl hydride, ...	1	2·0	1	2·0
Methyl, ...	1	3·5	2	2·5
Ethyl hydride, ...	1	3·5	2	2·5
Ethyl, ...	1	6·5	4	3·5
Propyl hydride, ...	1	5·0	3	3·0
Propylene, ...	1	4·5	3	2·5
Butyl hydride, ...	1	6·5	4	3·5
Butylene, ...	1	6·0	4	3·0
Acetylene, ...	1	2·5	2	1·5
Olefiant gas, ...	1	3·0	2	2·0

The atomic weight of each element in grams occupies 11·2 litres, excepting Hg, Zn, and Cd, which occupy 22·4 litres, and P and As, which occupy 5·6 litres.

The molecular weight of a compound in grams occupies 22·4 litres, unless its vapour density is abnormal.

The densities of most elementary gases are identical with their atomic weights, and the densities of most compounds are half of their weights.

The density of a gas is directly and the volume is inversely as the pressure which it sustains if the temperature remains constant.

In the same volume all gases and vapours contain the same number of molecules.

INDEX.

Acetamide, 17.
Acetates, 71, 103.
Acetic acid, 49, 50, 51, 54, 55, 61, 62, 69, 103, 122, 123, 129, 131, 136, 141, 182, 183, 184, 189, 198, 201, 263, 268.
Acetic aldehyde, 29, 62, 64, 200, 202, 227.
Acetic anhydride, 65, 75.
Acetic ether, 58, 71, 213, 264.
— — composition, 197.
Acetic ketone, 78.
Acetic series of acids, 68, 242.
Acetic series of alcohols, 67.
Aceto-benzoic anhydride, 75, 77.
Aceto-lactic acid, 68.
Acetones, 69, 71, 78, 79.
Acetyl chloride, 70.
Acetylene, 20, 23, 31, 45, 47, 49, 54, 182, 218, 221, 251, 253, 268.
Acetylide of copper, 23.
Acids, 58.
Acid salt, 36.
Aconitic acid, 69, 113, 260.
Acroleine, 115, 116, 130, 226, 267.
Acrylic acid, 22, 68, 115, 226, 255, 267.
Acrylic series, 67, 243.
Acrylic series of alcohols, 67.
Adipic acid, 69.
Adulterants, 87.
Alanin, 64, 65, 72.
Albumen, 64, 65, 72, 84, 105.
Alcoholates, 49.
Alcohols, 2, 22, 24, 31, 32, 35, 40, 46, 47, 48, 49, 51, 52, 53, 54, 55, 58, 59, 60, 62, 64, 66, 67, 78, 106, 184, 185, 198, 203, 205, 219, 220, 253.
Aldehydes, 2, 22, 49, 61, 63, 72, 122, 214, 223, 262, 268.
Ale, 49.
Alizaric acid, 69.
Alizarine, 252, 260, 261.
Alkalimides, 17.
Alkaline cyanides, 38.
— formiates, 40.
— hydric sulphites, 63.
Alkaloids, 3, 49, 60, 79, 80.
Allyl, 22, 194.
Allylamine, 14.
Allylene, 23.
Allyl ethylic ether, 22.
— series of acids, 22.
— sulphide, 22, 157.
— sulpho-cyanide, 156.
— sulphuric acid, 22.
Allylic alcohol, 235, 267.
— ether, 22, 53.
Almond-oil, 37, 151.
Alpha-cymic acid, 68.
Alpha-toluylic acid, 68.
Alpha-xylic acid, 68.
Amalic acid, 84.
Amides, 3, 17, 76.
Amido-acids, 64.
Amidogen, 17.
Amines, 3, 14.
Ammonia-boric methods, 259.
Ammoniacal water, 43.
— plumbic acetate, 121.
Ammonic acetate, 46, 71.
— cyanide, 38, 45.
— formate, 37, 38, 39.
— oxalate, 34, 35.
— sulphocyanide, 39.
— tartrate, 40.
Amygdaline, 37, 65.
Amylalcohol, 266.
Amylamine, 14.
Amylene, 23.
Amylenic bromide, 19.
— chloride, 19.
— oxide, 53.
Amylic alcohol, sp. gr., 217.
— ether, 52.
Amyl methylamine, 267.
— valerate, 267.
Anæsthetic, 54, 61.
Analysis, qualitative, 204.
Anchoic acid, 69, 149.
Angelic acid, 68.
Anhydrides, 74, 77.
Anhydrous ether, 56.
Aniline, 45, 51, 63, 81, 107, 121, 124, 260.
— chloride, 82.
— hydrochlorate, 50.
— purple, 82.
— rational formulæ, 10.
— sulphate, 82.
Anise camphor, 155.
Aniseed oil, 154.
Answers to questions set in organic chemistry, 182.
Anthracene, 45, 252.
Anthracite, 41.
Anthranilic acid, 81.
Antimonic triethoxide, 97.
Apparatus, 163, 171, 193.
Apricots, 37.
Arachic acid, 68.
Argentic cerotate, 117.
Argentic cyanide, 33, 37, 38.
— fulminate, 49.
— oxalate, 36.
Aromatic oil, 84.
Arsenic, 13.
— trimetho-dichloride, 25.
Arsines, 17, 80.
Artificial alkaloids, 80.
Asafoetida, essence of, 153, 157.
Aspartic acid, 261.
Atomicity of elements, 269.
Atomic weight, 274.
— — of elements, 269.
Aurantiaceæ, 154.
Aurine, 51.
Azobenzol, 124.

Balloon, 8.
Balsams, 77.
Baric acetate, 104.
Barium oxalate, 36.
Barometer, 8.
Basicity of organic acids, 235, 247.
Basic substance, 7.
Bear's grease, 148.

Beef marrow, 148.
Bee [illegible], 42.
Beer, 42.
Bees-wax, 30, 138.
Behenic acid, 68.
Benzamide, 17.
Benzenic acid, 68.
Benzene, 43, 108, 200.
Benzoates, 74.
Benzo-cinnamic anhy-dride, 76.
Benzo-glycollic acid, 115.
Benzoic acid, composition, 247.
— [illegible], 200.
— [illegible], 200, 283.
— anhydride, 75, 76.
— oxychloride, 76.
— series of acids, 56.
Benzol, 18, 22, 32, 42, 52, 82, 254.
Benzonitrile, 126.
Benzophenone, 31, 78.
Benzoyl chloride, 76.
Benzyl, 22.
Benzylic alcohol, 22, 66.
— chloride, 66, 262.
— ether, 22, 33.
Bergamot oil, 158.
Bile, 138.
Birch oil, 158.
Bisulphides, 17, 50.
Bitartrate of potash, 112.
Bitter almond oil, 37.
— almonds, 37, 65, 232.
Bitter-fennel oil, 161.
Bituminous coal, 41.
— shale, 33, 41.
Black colour, 82.
Blackening of organic compounds, 99, 112.
Black mustard, 153.
Bleaching-powder, 59.
Blood, 40, 139.
Blood-red liquid, 85.
Blowpipe, 98.
Blue colour, 82.
Blue writing ink, 40.
Boghead coal, 41.
Boiling, 98.
— points, 99.
Books, 44.
Boric binoxyethide, 94.
— ethide, 93.
— ethylate, 93, 259.
— methide, 93, 259.
Borneo camphor, 160.
Borneol, 162.
Brandy, 48.
Brassylic acid, 36.
Brazilian wax, 138.
Bromides of methyl radicals, 22.
Bromoform, 61.
Bronze-coloured substance, 83.
Brucine, 108.
Butane, 29.
Butter, 147.
Butyl, 227.
Butylamine, 14.
Butylene, 23, 31.
Butylenic bromide, 19.
— chloride, 19.
Butylic alcohol, 62.
— ether, 59.
— iodide, 257.
Butyric acid, 59, 67, 73, 109, 141, 252, 262, 263, 264, 268.
— aldehyde, 62.
— anhydride, 75.
— ether, 52, 115, 194.
— fermentation, 132.
Butyrin, 147.
Butyrone, 78.

Cacodyl, 243, 260.
— chloride, 97.
Cacodylic acid, 260, 261.
Caffeine, 83, 84, 109.
Cajeput, 153.
Caking coal, 41.
Calcic acetate, 70.
— benzoate, 31, 73.
— citrate, 196.
— lactate, 72.
— meconate, 87.
— oxalate, 36, 196.
— tartrate, 196.
Camphor, 30, 31, 153.
Camphoric anhydride, 76.
Canada balsam, 116.
Cane-sugar, 47, 72, 266.
Caoutchouc, 31.
Capric acid, 68.
— aldehyde, 63.
Caproic acid, 55, 67, 125, 220, 230.
— anhydride, 75.
Caproin, 147.
Caprylic acid, 67, 125.
— aldehyde, 63.
— anhydride, 75.
Caprylin, 147.
Caramel, 116.
Caraway oil, 159.
Carbinols, 22, 239.
Carbolic acid, 18, 22, 50, 110, 260.
Carbon bisulphide, 26, 43.
Carbonic anhydride, 44.
— ether, 90.
Carbonyl chloride, 89.
Carmine, 117.
Carvene, 159.
Carvol, 159.
Caryophyllin, 159.
Caseine, 64, 66, 73, 110.
Castor-oil, 150.
Caterpillar hairs, 40.
Cellulose, 266.
Centaury, 153.
Ceroleine, 138.
Cerotic acid, 68, 117, 138.
Cerotine, 23.
Cetine, 23.
Cetylene, 129.
Chalk, 87.
Chamomile oil, 158.
Charcoal furnace, 3.
Cherries, 37.
Cherry laurel, 37.
Chestnut leaves, 81.
Chinese wax, 138.
Chloracetamide, 17.
Chloracids, 18, 75, 78.
Chloral, 19, 59, 117.
— hydrate, 49, 118.
Chloride of calcium tube, 168.
Chlorides, 22.
— of methyl radicals, 22.
Chlorobenzol, 66.
Chlorocerotic acid, 117.
Chloroform, 26, 37, 39, 47, 49, 54, 59, 60, 61, 111, 118, 136, 183, 197, 255.
Chloropicrin, 118.
Chloropropionic acid, 72.
Chlorostearic acid, 130.
Chloro-substitution acids, 19.
Chlorotoluol, 261.
Cholesterine, 111, 139.
Chrysaniline, 16.
Chrysene, 45.
Cinchona-bark, 80, 86.
Cinchonine, 86, 111.
— sulphate, 118.
Cinnamic acid, 73, 252.
Cinnamon oil, 156.
Citraconic acid, 259.
Citramide, 17.
Citrate of iron and quinine, 87.
— of iron, 118.
— of lime, 119.
Citrates, 113.

Citric acid, 67, 69, 112, 113, 196, 252, 260.
Citryl triphenyl triamide, 18.
Clot, 139.
Cloves oil, 153, 159.
Coagulation, 99, 110, 120.
Coal, 27, 30.
Coal-gas, 41, 50, 245.
— composition, 45.
— retorts, 41.
Coal-tar, 50.
— naphtha, 82.
Cobalt cyanide, 38.
Cochineal, 48.
Cocoa-nut oil, 148.
Codeine, 88.
Cod-liver oil, 150.
Coffee, 80, 84.
Coke, 41.
Colophene, 157.
Colopholic acid, 128.
Colour, 98.
Colza-oil, 151.
Combustible gases, 273.
Combustion, 3.
— furnace, 166.
— tube, 167.
Composition, 195.
— percentage, 205, 215, 216.
Compound inorganic radicals, 1.
— organic radicals, 1, 20.
Confectionery, 59.
Conine, 15.
Constitutional formula, 242, 254.
Convolvulinoleic acid, 68.
Copper acetylide, 23.
Corpuscles, 139.
Corrosive sublimate, 111.
Cotarnine, 124.
Cotton-seed oil, 148.
Cream of tartar, 119.
— flavouring, 59.
Creosote, 50, 110, 119.
Creosotic acid, 68.
Crotomylene, 23.
Crotonic acid, 68.
Crystalline form, 98.
Crystallization, 87, 88, 89, 90, 91, 123.
Crystals, 86, 90, 91, 111, 113, &c.
Cubebine, 160.
Cubebs oil, 160.
Cumene, 45.
Cuminic acid, 68, 155.
— oxychloride, 76.
Cumin oil, 160.
Cupric potassic tartrate, 120.
— sulphate, 110.
Custards, 59.
Cyamelide, 90.
Cyanate of ammonium, 268.
Cyanethine, 28, 268.
Cyanhydric glycol, 241, 258.
Cyanic acid, 91, 268.
— ether, 14, 28.
Cyanide of ethyl, 268.
Cyanides, 22, 38.
Cyanogen, 12, 20, 33, 34, 35, 36, 38, 44, 49, 191, 200, 217.
Cymene, 45.

Damaluric acid, 68.
Damolic acid, 68.
Decomposition, 99.
Definition of organic chemistry, 1.
Density of gases, 274.
Detection of acids, 195.
Dextrine, 72, 120, 129, 266.
Dextro-tartaric acid, 135.
Diacetamide, 17, 18.
Diacetyl chloral hydrate, 117.
Diad radicals, 20, 23.
Diamides, 17.
Diamines, 14, 16, 80.
Dibasic acids, 17, 34, 36, 66, 69, 74.
— anhydrides, 74.
Dibrombenzol, 18.
Dibromo-succinate of silver, 235.
Dibromo-succinic acid, 120.
Dibutylamine, 15.
Dichloraniline, 82.
Dichlorbenzol, 18.
Dichlorinated ether, 55.
Dichlorobutyric acid, 109.
Diethoxalic acid, 68.
Diethylamine, 15, 229, 254.
Diethylated ethylic ether, 96.
Diethylene diamine dichloride, 64.
Diethyl oxamide, 17.
— phosphine, 17, 97.
— phosphoric zincic iodide, 97.
Dihydric series of alcohols, 23.
Dimethoxalic acid, 68.
Dimethylamine, 15.
Dimethylaniline, 15.
Dimethyl arsenic trichloride, 97.
Dimethylcumidine, 15.
Dimethylcymedine, 15.
Dimethylethyl carbinols, 22.
Dimethyl phosphine, 17, 97, 251.
Dimethyltoluidine, 15.
Dimethylxylidine, 15.
Dinitrobenzol, 18.
Diphenyl oxatyl carbonyl diamide, 18.
Diphenyl rosaniline, 16.
Disinfectants, 110.
Distannic ethodiiodide, 97.
Distannic iodo-diethide, 97.
Distillation, 99, 169, 170.
— of coal, 41.
Disulphanthroquinonic acid, 252.
Disulpho-benzolic acid, 108.
Ditritylamine, 267.
Doeglic acid, 68.
Dominant element, 24.
Double cyanides, 38.
Dripping, 147.
Drying oils, 146.
Dumas' method for determining the specific gravity of vapours, 163, 261.
Dutch liquid, 33, 184.
Dyeing, 82.

Elaeopten, 153.
Elaidic acid, 68, 125.
Elaidine, 125, 145.
Elaldehyde, 65.
Elements, 269.
Elemi oil, 161.
Elm leaves, 81.
Emeraldine, 83.
Empirical formula, 3, 7, 9, 184, 192, 194, 196, 198, 202, 223.
Emulsion, 37, 65, 130.
English cannel coal, 41.
Erlenmeyer's furnace, 5, 167.
Erucic acid, 68.
Essential oils, 47, 49, 65, 84, 144, 153.
Ether, 12, 22, 24, 30, 32, 46, 51, 53, 54, 58, 59, 60, 64, 66, 71, 194, 214.

Ether, anhydrous, 56.
— dichlorinated, 55.
— perchlorinated, 55.
Ethereal salts, 57, 200.
Ethers, 22, 30, 52, 54.
Ethine, 237.
Ethomethoxalic acid, 68.
Ethyl, 23, 29, 45, 52.
— acetamide, 17.
Ethylamine, 14, 15, 254.
— hydrochlorate, 255.
Ethylammonic iodide, 254.
Ethylamylamine, 15.
Ethylamylic ether, 52, 54.
Ethylated acetone, 78, 258.
Ethyl butylic ether, 52.
— butyral, 78.
— butyrate, 194.
— butyryl, 266.
— capylate, 267.
— chlorether, 96.
— chloride, 47, 49, 55.
— crotonic acid, 68.
— diacetamide, 17.
— diamine, 16.
Ethylene, 20, 23, 29, 32, 33, 45, 49, 61, 195, 225, 233.
— cyanide, 23.
— diamine, 23.
— dibromate, 237.
— dichloride, 33, 184, 266.
— diethyl diamine, 16.
— series, 20, 24, 51
Ethylenic bromide, 61.
— dibromide, 203.
— iodide, 19.
— oxide, 23, 29, 53, 250, 262.
— series of alcohols, 23.
Ethyl hydride, 28, 29, 47.
— lactic acid, 68.
— methyl ether, 57.
Ethylic abnormal cyanide, 255.
— α cyanopropionate, 258.
— acetate, 202, 262, 263, 264.
— alcohol, 47, 50, 52, 53, 59, 62, 200, 201, 233, 267.
— butyrate, 200.
— chloride, 183.
— cyanide, 190, 255.
— ether, 52, 53, 61, 200.
— iodide, 28, 29, 33, 56, 57, 232.
— nitrile, 63, 253.
— oxalate, 36.
— stearate, 130.
Ethylidenic cyanhydrate, 72.
— dichloride, 64.
Ethylphenylamine, 15.
Ethyl phosphine, 17, 97.
— phosphoric iodide, 98.
— trityl, 267.
— urea, 16.
Ethyrite, 257.
Eudiometrical apparatus, 164.
Eugenic acid, 159.
Euodic aldehyde, 13, 162.
Evaporation, 98.
Exercises, 172–181.
Extractive matter, 84.

Fat, 31, 47, 49, 55, 60.
Fats, 145.
Fatty acids, 22, 78.
Fehling's fluid, 142.
Fermentation, 47, 110, 132, 133.
Ferric acetate, 71, 104.
— citrate, 118.
Fibre, 84.
Fibrine, 64, 66, 141.
Fibrinogen, 139.
Fibrinoplastin, 139.
Fish-oil, 148.
Fixed oils, 3, 144.
Flatulence, 54, 157.
Flavouring confectionery, 66.
Florence-oil, 151.
Fluorescence, 87.
Formiates of heavy metals, 40.
Formic acid, 8, 9, 33, 35, 38, 39, 47, 62, 66, 136, 183, 187, 192, 217.
— aldehydes, 62.
— ether, 29.
Fractional distillation, 169.
Frankland and Ward's eudiometrical apparatus, 164, 165.
Fumaric acid, 69, 120, 121, 122, 266.
— series of acids, 69.
Furniture, 44.

Gallates, 113.
Gallic acid, 113, 134.
Gallipoli oil, 151.
Gall-nuts, 81.
Garlic oil, 156, 157.
Gas yield from coal, 41.
Gases, 49.
Gas-furnace, 3.
Gas-holder, 43.
Gastric juice, 141.
Gay-Lussac's method for determining the specific gravity of vapours, 164, 261.
Geissler's potash apparatus, 170.
Gelatine, 66, 114.
Glass tube for weighing, 169.
Globe, four-necked, 169.
Globulin, 139.
Glucose, 37, 258.
Gluten, 73.
Glyceric acid, 68.
Glycerine, 23, 39, 114, 130, 144, 235, 237, 254.
— series of alcohols, 67.
Glycocholic acid, 138.
Glycocine, 267.
Glycocoll, 114, 115.
Glycogen, 142, 266.
Glycol, 62, 219, 224, 234, 237.
— series of alcohols, 67.
Glycomalic acid, 69.
Glycylic ether, 53.
Glyoxal, 62.
Glyoxalic acid, 49.
Glyoxylic acid, 68.
— series of alcohols, 67, 68.
Gold cyanide, 38.
Grape-sugar, 48, 128, 129, 132, 266, 268.
Graphic formulæ, 25, 185, 188, 189, 197, 199, 201, 204, 213, 215, 218, 221, 224, 228, 230, 233, 234, 240, 241, 254, 255, 257, 259, 263.
Grease, 41, 147.
Green colour, 82.
Green tea, 81.
Ground-nut, 89.
Gum, 72, 87, 266.
— arabic, 120.
— benzoin, 50, 73.
Gummic acid, 120.
Gutta-percha, 31.
Gypsum, 87.

Hæmatin, 139.
Hæmoglobin, 140.
Halogens, 13.
Haloid ethers, 19, 55, 202, 203.
Headaches, 59.
Heat, 98.
Hemimellitic acid, 257.

Heptylene, 23.
Heptyl propionate, 267.
Hexahydrophthalic acid, 69.
Hexylamine, 267.
Hexyl butyrate, 267.
— hydride, 267.
Hexylene, 23.
Hippuric acid, 73, 115.
Hog's lard, 148.
— oil, 158.
Horse radish, 153.
Hyænic acid, 68.
Hydraulic main, 43.
Hydric ammonic oxalate, 36.
Hydricity of acid, 247.
Hydride of benzoyle, 66.
Hydrides, 21.
Hydriodic ether, 55.
Hydrobromic ether, 55.
Hydrocarbons, 2, 23, 44, 45, 46, 49.
Hydrocele, 141.
Hydrochloric ether, 24, 55.
Hydrocyanic acid, 2, 34, 37, 38, 39, 64, 65, 183.
Hydroferrocyanic acid, 40.
Hydrosulphuric ether, 24.
Hypostannic ethide, 97.

Ices, 59.
Identification of organic compounds, 98, 99, 100, 101, 102, &c.
Illuminating ingredients, 45.
— power, 41, 44.
Imides, 18.
Inactive tartaric acid, 235.
Indigo, 81, 98, 121, 247.
— white, 121.
Ink, 40.
Inorganic chemistry, 1.
Insensibility, 54.
Insoluble in water, 99.
Intoxication, 54, 84.
Iodides of methyl radicals, 22.
Iodoform, 61.
Iron purifiers, 43.
Isomalic acid, 266.
Isomeric, 248.
Isomerism, 29, 47, 254, 257, 262.
Isopropacetic acid, 265.
Isopropylic alcohol, 223, 254, 266.
Isotartaric acid, 134.
Isoterebenthine, 157.
Isovaleric acid, 265.
Itaconic acid, 89, 259, 260.

Jalapinoleic acid, 68.
Juniper oil, 161.

Ketones, 19, 78, 79, 223.
Kidney fat, 148.
Kitchen waste, 41.
Kola-nuts, 84.
Kreatine, 80.
Kreatinine, 80.

Labiatæ leaves, 154.
Lactannic acid, 64, 65.
Lactic acid, 64, 65, 68, 71, 72, 121, 139, 141, 143, 213, 219, 220, 223, 239, 254, 266, 267, 268.
— composition, 199.
Lactic fermentation, 132.
— series of acids, 67, 68, 243.
Lake aniline, 16.
Lamp-burning oil, 152.
Lard, 148.
Laudanosine, 88.
Laurel aldehyde, 162.
Lauric acid, 67.
— aldehyde, 63.
Lavender oil, 160.
Lead oxalate, 36.
Leather, 152.
Lemon oil, 161.
Leucic acid, 68, 268.
Leucine, 114.
Leucoline, 45.
Lime purifiers, 43.
Linseed-oil, 149.
Liqueurs, 154.
Liquid tar, 43.
Liquor sanguinis, 139.
Lithic zincic ethide, 97.
Lithio-mercuric ethide, 97.
Locomotive grease, 147.
London gas, 41.
Lozenges, 88.
Lubrication of rolling stock, 147.
Lungs, 59.
Lupuline, 159.
Lupulite, 159.

Machinery oil, 151.
Magenta, 83.
Magnesia, 87.
Magnesic ethide, 97.
Main-pipe, 43.
Malacic acid, 121.
Malic acid, 69, 121, 238, 262, 266.
— anhydride, 76.
— series of acids, 69.
Malonic acid, 36, 69.
Mannite, 258.
Mare's grease, 148.
Margaric acid, 68.
Margarine, 148, 151.
Marine soap, 149.
Marsh-gas, 10, 21, 25, 46, 49, 59, 71, 182, 185, 189, 192, 215.
Mauve, 82.
Meconic acid, 88, 122.
Melassic acid, 133.
Melene, 23.
Melissic acid, 22, 68.
Mellitic acid, 19, 67, 69.
Mercaptans, 22, 23, 24.
Mercuric amychloride, 97.
— amyiodide, 97.
— amylide, 97.
— cyanide, 33, 34, 37, 38.
— ethchloride, 97.
— ethide, 97.
— ethiodide, 97.
— ethnitrate, 97.
— methide, 260.
— methiodide, 97.
Mercury ethide, 97, 249, 256.
— oxalate, 36.
Mesaconic acid, 259.
Metagallic acid, 134.
Metaldehyde, 65.
Metameric, 248.
Metamerism, 262.
Metatartaric acid, 134.
Metaterebenthine, 157.
Methacrylic acid, 68.
Methane, 25.
Methenyl ammonic chloride, 38.
Methethacetic acid, 265.
Methoxyl, 18.
Methyl, 14, 27, 28.
— acetate, 29, 46.
— acetone, 19.
— alcohol, 31, 39, 46, 52, 59, 61, 62.
— amyl, 267.
— arsenic tetrachloride, 97.
— crotonic acid, 68.
Methyl and ethyl tube, 168.
Methylacetate, 69.
Methylamine, 14, 84.
Methyl amylic ether, 52.

Methyl benzole, 78.
— bichloride, 61.
Methylated acetone, 78.
Methylated spirit, 47.
Methylenic iodide, 19.
Methyl ether, 47, 52, 267.
Methylethylamine, 15.
Methyl ethyl carbinols, 22.
Methylethylic ether, 52.
Methylethylphenylamine, 15.
Methyl glycolic acid, 68, 255, 266.
— hydride, 21, 25, 45, 60.
— iodide, 27, 47, 57.
— pelargonate, 267.
— phosphine, 97.
— series, 20, 51, 52.
— series of alcohols, 67.
Methylic alcohol, 183.
— chloride, 34, 46, 47, 59, 60, 61.
Methyl phosphine, 97, 251.
— uramine, 80.
— valeryl, 266.
Metrical weights and measures, 270.
Milfoil, 153.
Milk, 142, 143.
— sugar, 72.
Millon's reagent, 110.
Minerals, 84.
Mixed anhydrides, 76.
Molecular composition, 253.
— formulæ, 227.
— weight, 9, 10, 223, 259, 274.
Monacetic dycol, 61.
Monad radicals, 20.
Monamides, 17.
Monamines, 14, 80.
Monobasic acids, 34, 66, 67.
— anhyrides, 74.
Monobrombenzol, 18.
Monobromorcin, 18.
Monochloraniline, 82.
Monochlorbenzol, 18.
Monochlorethyl chloride, 266.
Monohydric alcohols, 22.
Moringic acid, 68.
Morphine, 10, 87, 88, 122, 123, 191.
— acetate, 88, 123.
— citrate, 88.
— hydrochlorate, 88, 123.
Mountain ash, 37.
Mucic acid, 120, 121.
Mucin, 144.
Muscles, 40.
Mustard oil, 156.
Myosin, 144.
Myricin, 138.
Myristic acid, 68, 147.
Myronic acid, 155.
Myrosin, 155.
Myrtaceæ leaves, 154.

Naphtha, 30, 31.
Naphthaline, 31, 44, 45, 49, 73, 123, 254.
Narcotic poison, 48.
Narcotine, 88, 124.
Natural alkaloids, 80.
Neat's-foot oil, 152.
Negative radicals, 20, 23.
Nervous debility, 157.
Newcastle coal, 41.
Nicotine, 85.
Nicotine oxalate, 85.
Nitraniline, 82.
Nitric ether, 24.
Nitrides, 18.
Nitrite of ethyl, 268.
Nitrobenzoic acid, 66.
Nitrobenzol, 18, 32, 81, 124.
Nitrobenzonitrile, 116.
Nitrobutyric acid, 109.
Nitrogen, to estimate, 273.
Nitrogenous substances, 11, 24.
Nitrotoluol, 81.
Nitrous ether, 49.
Nitrovaleric acid, 137.
Non-drying oils, 146.
Non-nitrogenous compounds, 24.
Non-saturated compounds, 240.
Non-volatile organic acids, 99.
Nonylene, 23.
Nonyl formiate, 267.
Normal acids, 36.
— alcohols, 78, 246.
— monohydric alcohols, 22.
Notation of organic compounds, 24, 25.
Nux vomica, 80, 88, 89.

Oak bark, 81.
Octyl acetate, 267.
Octylene, 23.
Odour, 98.
Œnanthic aldehyde, 63.
Œnanthylic acid, 55, 67.
Œnanthylic anhydride, 75.
Oil, 30, 41, 49, 50, 55.
— bath, 8.
— essential, 50.
— of almonds, 65.
— of bitter almonds, 73.
— of turpentine, 30, 157.
— pine-apple, 59.
Oils, 144, 145.
Olefiant gas, 49, 54, 68.
Olefine crotonic acid, 68.
Olefines, 268.
Oleic acid, 124, 139, 235.
— series of acids, 68.
— series of alcohols, 67.
Oleine, 125.
Olive green, 83.
— oil, 30, 151.
Opianic acid, 124.
Opium, 80, 88.
Orange, 158, 161.
— peel, 87.
Orcin, 18.
Organic acid, definition, 193, 202.
Organic acids, 66.
— identification, 191.
Organic analysis, 3.
— bases, 79.
— chemistry, definition, 1.
— substances, 9, 102.
Organo-boron compounds, 18, 93.
Organo-metallic compounds, 95, 97, 256.
Organo-silicon compounds, 91.
Oxalic acid, 11, 12, 33, 34, 35, 36, 40, 49, 51, 54, 56, 66, 72, 120, 121, 123, 130, 134, 137, 186, 187, 191, 201, 205, 217.
Oxalic ether, 216.
Oxamic acid, 36.
Oxamide, 17, 36.
Oxatyl, 17, 20, 34, 35, 66, 203.
Oxybutyric acid, 68.
Oxygen essences, 153.
Oxyhæmoglobin, 140.

Painting oil, 150.
Paints, 149.
Palenitic anhydride, 75.
Palmitic acid, 68, 125, 129.
— aldehyde, 63.
Palmitine, 126.
Palm oil, 149.
Pancreatic juice, 142.
Papaverine, 88.

Papers set in organic chemistry, 182.
Paracyanogen, 34.
Paraffine, 2, 30, 45.
— series, 21, 24.
Paralactic acid, 68, 254, 266.
Paraldehyde, 65.
Paraleucic acid, 68.
Paramylene, 23.
Parsley, 153.
Peach, 37.
Peat, 30, 41.
Pelargonic acid, 55, 67, 152.
— anhydride, 75.
Pentabasic acid, 69.
Pentad nitrogen, 24.
Pepper, 80.
Pepsin, 141.
Peptones, 142.
Percentage composition, 195.
Percentage weight, 8.
Perchlorinated ether, 55.
Perfumes, 59.
Petroleum, 30.
Phenol, 260.
Phenyl, 14, 22, 200.
— aldehyde, 22.
Phenylamine, 14.
Phenyl benzyl ether, 22.
— bromide, 73.
— chloride, 22.
— cyanide, 22, 73.
— hydride, 31.
— iodide, 16.
— rosaniline, 16.
— series, 20, 22, 51, 53.
— — of alcohols, 67.
Phenylene, 20, 23.
— series, 23.
Phenylic alcohol, 22, 45, 50.
— bromide, 200.
— ether, 22, 53.
— hydride, 18.
Phosphines, 17, 80, 96.
Phospho-glyceric acid, 139.
Phosphorescence, 87.
Phosphorus, 13.
Phthalic acid, 19, 31, 73, 123, 261.
— anhydride, 76.
Physetoleic acid, 68.
Picoline, 45.
Picric acid, 50, 98, 126.
Pimaric acid, 128.
Pimelic acid, 69.
Pine-apples, 59, 109.
Pine-apple oil, artificial, 59.
Pinic acid, 128.
Piperdine, 15.
Pitch, 31.
— oil, 148.
Plantain, 153.
Plaster, 147.
Platinic cyanide, 38.
Plumbic acetate, 103.
— caffeotannate, 83.
— chlortriethide, 97.
— ethide, 97.
— formiate, 39.
— tribasic acetate, 104.
Plums, 37.
Poison, 85, 89, 135.
— antidote, 81.
Polarization, 87, 88, 102, 116, 120, 121, 132, 161.
Polyad radicals, 23.
Polybasic acids, 66.
Polymeric, 248.
Polymerism, 262.
Poppy oil, 150.
Porter, 49.
Potassic acetate, 9, 28, 58, 61, 63, 125, 130, 231, 239, 252, 263.
— angelate, 158.
— benzoate, 31, 66, 252.
— butyrate, 254.
— cuminate, 160.
— cyanide, 28, 34, 36, 37, 38, 63, 126, 198, 199, 214, 255.
— diacetate, 70.
— ferricyanide, 98.
— ferrocyanide, 34, 36, 40, 98, 126, 127, 232.
— formiate, 63, 130, 189, 194.
— oxalate, 35, 36, 130, 199.
— palmitate, 125, 241.
— phenate, 50.
— propionate, 63, 198, 253.
— salicylate, 128.
— sulphovinate, 255.
— trichloracetate, 60.
— valerate, 227.
— zincic ethide, 97.
— — methide, 97.
Potassium ethylate, 49.
Primary diamides, 17.
— monamines, 15.
Printers' ink, 149.
Proof spirit, 48.
Propene, 45.
Propione, 78, 243, 248.
Propionic acid, 29, 67, 115, 267.
— aldehyde, 62.
— anhydride, 75.
Propylene, 23.
Propylenic bromide, 19.
— chloride, 19.
— iodide, 19.
— oxide, 53.
Propylic alcohol, 62, 235, 266.
— aldehyde, 267.
Prussian blue, 39, 40, 126.
Prussic acid, 65, 66, 186.
Ptyalin, 143.
Purple, 82.
Putrefaction, 110.
Pyrogallic acid, 127, 134.
Pyrogallin, 113.
Pyromellitic acid, 19, 67, 69.
Pyrotartaric acid, 69.
Pyroterebic acid, 68.
Pyruvic acid, 68, 72, 239.
— series of acids, 68.

Quanidine, 80.
Quantitative analysis, 3, 244, 245.
Quartene, 45.
Quinic acid, 31.
Quinine, 10, 86, 127.
— sulphate, 86, 87.
Quinoline, 86.

Radical compound, 213, 215.
Radicals, 52.
Rancidity, 147, 149, 151, 152.
Rape oil, 152.
Rational formulæ, 7–10, 229, 254.
Reagents, 100.
Red ants, 40, 146.
Refraction, 107, 116, 119.
Rennet, 111.
Resin, 30, 47, 49, 60.
Retorts, 169.
Ricinate of glyceryl, 150.
Ricinoleate, 150.
Ricinoleic acid, 68.
Ricin stearate, 150.
Rocellic acid, 36, 69.
Rochelle salt, 128.
Rosaceæ, 154.
Rosaniline, 16, 83.
Rose colour, 89.
Roseine, 83.
Rosin, 41, 128.
Ruby-red liquid, 85.

Rue oil, 162.
Rufigallic acid, 113.
Rum, 59.
Rutic acid, 267.

Saccharic acid, 120, 134.
St. Ignatius bean, 89.
Salad oil, 151.
Salicine, 87, 128.
Salicylic acid, 50.
Saligenin, 128.
Saliva, 143, 144.
Saponification, 146, 152.
Satisfied bonds, 21.
Savine oil, 161.
Scotch coal, 41.
Scotch parrot coal, 41.
Scurvy-grass, 153.
Sebacic acid, 69, 125.
Secondary alcohol, 246.
— monamines, 14.
— monohydric alcohols, 22.
Serum, 139.
Sesame oil, 152.
Sewage, 51.
Shale, 41.
Silicic chloroform, 92.
— chlortriethide, 93.
— dichlorethide, 93.
— dimethylate diethylate, 93.
— ethide, 96.
— ethylate, 93.
— methide, 92.
— methylate, 93.
— oxalic acid, 92.
— propionic acid, 92.
— triethohydrate, 93.
— triethylate, 93.
Silicoformic acid, 92.
Siliconylic alcohol, 93, 237.
Silver acetate, 237.
— cyanide, 37.
Single cyanides, 38.
Sleepiness, 54.
Sloe, 37.
Soap, 49, 66, 128–130.
— boiling oil, 150.
— scenting, 66.
Sodic butyrate, 59.
— cyanide, 28.
— ethide, 232.
— formiate, 40, 65.
— isosuccinate, 258.
— oxalate, 35, 40, 196.
— paralactate, 258.
— phenate, 50.
— stearate, 130.
— zinzic ethide, 97.
Sodium acetate, 25, 58, 70, 79, 105.
— cinnamate, 77.
— ethylate, 49, 203.
Soluble in alcohol, 101, 102.
— in ether, 101, 102.
— in water, cold or boiling, 99, 100, 101, 102.
Specific gravity, 7.
— — of elements, 269.
— — of vapours, 163.
Spermaceti, 30, 129.
Sperm oil, 148, 152.
Spiræa oil, 155.
Stannic diethodimethide, 97.
— ethide, 97.
— ethodichloride, 97.
— ethodiodide, 97.
— iododimethide, 97.
— iodotrimethide, 97.
— methide, 97.
— phenoethyldichloride, 97.
— phenyl triethide, 97.
— triethobromide, 97.
Stannous methide, 97.
Starch, 39, 72, 129, 266.
Stearic acid, 68, 87, 130, 254.
Stearine, 31, 130.
— candles, 148.
Stearopten, 154.
Stibines, 17, 80.
Stilbene, 23.
Stinging nettle, 40.
Strychnine, 88, 89, 131.
— sulphate, 88.
Styrol, 73.
Suberic acid, 69, 130.
Sublimation, 99.
Substitution, 14.
— products, 27, 51.
Succinamide, 17, 18.
Succinic acid, 74, 120, 122, 131, 136, 248, 251.
— anhydride, 76.
— series of acids, 69.
Succinimide, 18.
Suet, 148.
Sugar, 3–5, 7, 45, 49, 120, 130, 132, 133, 138, 198.
-- cane wax, 138.
Sulphides, 22.
Sulpho-acid, 52.
Sulpho-benzolic acid, 108.
Sulpho-saccharic acid, 133.
Sulphovinic acid, 54, 63.
Sulph-phenyl urea, 16.
Sulphur, 13.
— essences, 153.
Sulphuretted hydrogen, 43.
Sulphur urea, 16.
Superacid salts, 36.
Surgical operations, 61.
Sylvic acid, 128, 134.
Symbolic formulæ, 185, 188, 189, 199, 201, 204, 241.
— notation, 24.
Symbols of elements, 269.
Synaptase, 65.
Syntonin, 144.

Tallow, 226, 254.
Tannic acid, 80, 134.
Tannin, 84.
Tar, 30, 46, 50, 69, 70.
Tartar emetic, 136.
Tartaric acid, 38, 39, 69, 71, 120, 132, 134, 201, 222, 251, 266.
— anhydride, 76.
— series of acids, 69.
Tartrate of soda and potash, 128.
Tartrelic acid, 134.
Tartronic acid, 69.
Tartrophthalic acid, 169.
Taste, 98.
Taurocholic acid, 138.
Tea, 81, 84.
Telluric methide, 97.
Terebene, 157.
Terebenic acid, 158.
Terebic acid, 128.
Tertiary alcohol, 246.
— monamine, 15.
— monohydric alcohols, 22.
Tetrachlorobutyric acid, 109.
Tetrahydrophthalic acid, 69.
Tetramines, 14, 80.
Tetrethyl antimonic hydrate, 97.
— arsenic chloride, 97.
Tetryl, 137.
— caproate, 267.
— dimethylamine, 267.
— ethylamine, 267.
Theine, 83.
Thymene, 162.
Thyme oil, 162.
Thymoil, 162.
Thymol, 162.
Tobacco, 80, 85.
Toluene, 45.

Toluic acid, 68.
Toluidine, 16, 256.
Toluylic acid, 256, 257.
Tolylamine, 14.
Tolylformamide, 256.
Tolylnitrile, 256.
Tonic, 158.
Triad elements, 24.
— radicals, 20, 23.
Triamides, 11, 17.
Triamines, 14, 80.
Triamylamine, 15.
Triamyl stibines, 17, 97.
Tribasic acids, 17, 35, 66, 69, 74.
— anhydrides, 74.
— plumbic acetate, 120.
Tribrombenzol, 18.
Tribrominated amines, 18.
Tributylamine, 15.
Tricarballylic acid, 69, 113, 252.
Tricetylamine, 267.
Trichloracetic acid, 117.
Trichloraniline, 18, 82.
Trichlorbenzol, 18.
Trichlorinated amines, 18.
Triethylamine, 15, 267.
Triethyl arsenic dichloride, 97.
— arsine, 17, 97.
— bismuthine, 17, 97.
— phosphine, 17, 77, 97, 243.
— phosphoric iodide, 97.
— rosaniline, 16.
— stibine, 17, 97.
Trihydric alcohols, 23.
Trimellitic acid, 19, 257.
Trimesic acid, 257.
Trimethacetic acid, 265.
Trimethylamine, 15.
Trimethyl arsine, 17, 97.
— bismuthine, 17.
— phosphine, 17, 97, 251.
Trinitro orcinic acid, 18.
Trinitrophenylic acid, 50.
Triphenyl rosaniline, 16.
Tritolyl rosaniline, 16.
Tritylene oxide, 267.
Trityl ethyl ether, 266.
— — methylamine, 267.
— methyl ether, 266.
— œnanthate, 267.
— trityl, 267.
Turpentine, 31.
— oil, 157.

Umbelliferæ seeds, 154.
Unsatisfied bonds, 21.
Urea, 16, 80, 90, 136, 137, 182, 268.
— nitrate, 136.
— oxalate, 136.
Uric acid, 136.
Urine, 40, 80.

Valerian oil, 160.
— root, 146.
Valeric acid, 67, 137, 216, 264, 265.
— aldehyde, 63.
— anhydride, 75.
Valerol, 158.
Valerolactic acid, 68.
Valerylene, 23.
Vapour, 7, 10, 11.
— density, 10.
Varnish, 47, 149.
Veal fat, 148.
Vegetable acids, 49.
— alkaloids, 80.
Vinegar, 70.
Vinic alcohol, 29.
Vinyl, 14.
Vinyl aldehyde, 22.
— series, 20, 22, 51, 53.
— — of alcohols, 67.
Vinylic bromide, 19, 61.
Violet colour, 82.
Violine, 83.
Virgin oil, 151.
Volatile liquid bulbs, 167.
— monobasic acids, 78.
— organic acids, 99.
Volume of gases, 274.

Waggon grease, 148.
Walnut oil, 146.
Wasp poison, 40.
Water of crystallization, 87.
Wax, 30, 31, 137.
Weight, 220.
— of a substance, to find, 273.
Whisky, 48.
Wine, 49.
Winter-green oil, 155.
Wood, 30, 41, 46.
— naphtha, 69.
Wood-tar oils, 30.
Woody fibre, 39.
Woollen stuffs, 152.

Xanthorrhœa hastilis, 50.
Xylene, 45.
Xylic acid, 68.

Yeast, 48, 206–212.

Zinc amylide, 97.
— dinitro-ethylate, 96.
— ethide, 79, 95, 96, 249.
— ethyl, 29.
— ethylate, 256, 97.
— lactate, 71.
— methide, 26, 95, 97.

THE END.

GLASGOW: W. G. BLACKIE AND CO., PRINTERS, VILLAFIELD.